2017 U.S. NATIONAL CHEMISTRY OLYMPIAD

LOCAL SECTION EXAM

Prepared by the American Chemical Society Chemistry Olympiad Examinations Task Force

OLYMPIAD EXAMINATIONS TASK FORCE

Seth N. Brown, **Chair**, *University of Notre Dame*, Notre Dame, IN

James Ayers, *Colorado Mesa University*, Grand Junction, CO
Mark DeCamp, *University of Michigan*, Dearborn, MI (retired)
Marian DeWane, *Centennial High School*, Boise, ID
Xu Duan, *Holton-Arms School*, Bethesda, MD
Valerie Ferguson, *Moore HS*, Moore, OK
Julie Furstenau, *Thomas B. Doherty HS*, Colorado Springs, CO
Kimberly Gardner, *United States Air Force Academy*, CO
Paul Groves, *South Pasadena HS*, South Pasadena, CA
David W. Hostage, *Taft School*, Watertown, CT
Dennis Kliza, *Kinkaid School*, Houston, TX
John Kotz, *State University of New York*, Oneonta, NY (retired)
Jane Nagurney, *Scranton Preparatory School*, Scranton, PA
Sheila Nguyen, *Cypress College*, Cypress, CA
Ronald Ragsdale, *University of Utah*, Salt Lake City, UT (retired)

DIRECTIONS TO THE EXAMINER

This test is designed to be taken with an answer sheet on which the student records his or her 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.

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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
$R = 8.314$ J mol^{-1} K^{-1}
$R = 0.08314$ L bar mol^{-1} K^{-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 atm = 1.013 bar = 760 mm Hg
Specific heat capacity of H_2O = 4.184 J g^{-1} K^{-1}

EQUATIONS

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

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** 78.97	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** 95.95	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 **Nh** (286)	114 **Fl** (289)	115 **Mc** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (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)

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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. Glyoxal consists of 41.4% C, 3.5% H, and 55.1% O by mass. What is the empirical formula of glyoxal?

(A) CHO **(B)** CH_2O

(C) CH_2O_2 **(D)** $C_{12}HO_{16}$

2. How many hydroxide ions are in 2.5 mol $Mg(OH)_2$?

(A) 3.0×10^{23} **(B)** 6.0×10^{23}

(C) 1.5×10^{24} **(D)** 3.0×10^{24}

3. In a sample consisting of 1.00 mol NaBr and 0.300 mol KI, what is the mass percent of iodine?

(A) 24.9% **(B)** 32.6% **(C)** 47.2% **(D)** 83.1%

4. What is the concentration of chloride ions in a solution formed by mixing 150. mL of a 1.50 M NaCl solution with 250. mL of a 0.750 M $MgCl_2$ solution?

(A) 0.563 M **(B)** 1.03 M

(C) 1.50 M **(D)** 2.25 M

5. Barium chloride reacts with sodium sulfate according to the following equation:

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2\ NaCl(aq)$$

A student mixes a solution containing 10.0 g $BaCl_2$ (M = 208.2) with a solution containing 10.0 g Na_2SO_4 (M = 142.1) and obtains 12.0 g $BaSO_4$ (M = 233.2). What is the percent yield of this reaction?

(A) 60.0%

(B) 73.1%

(C) 93.3%

(D) The isolated barium sulfate is most likely wet, since the yield would otherwise be greater than 100%.

6. Which aqueous solution has the highest boiling point?

(A) 1.0 *m* acetic acid, CH_3COOH

(B) 1.0 *m* sulfuric acid, H_2SO_4

(C) 1.0 *m* phosphoric acid, H_3PO_4

(D) 1.0 *m* glucose, $C_6H_{12}O_6$

7. A white ionic solid is dissolved in water. Addition of a solution of sodium chloride to this solution results in a white precipitate. What was the cation in the original ionic solid?

(A) Na^+ **(B)** Fe^{3+} **(C)** Ag^+ **(D)** Sr^{2+}

8. An element is a solid at room temperature but soft enough to be cut with an ordinary knife. When placed in water, the element reacts violently. What element is it?

(A) Na **(B)** Mg **(C)** Cu **(D)** Hg

9. A 0.1 M solution of which salt is the most basic?

(A) $NaNO_3$ **(B)** $NaClO_4$

(C) $NaHSO_4$ **(D)** $NaHCO_3$

10. Addition of small amounts of which solids to 4 M HCl will result in gas evolution?

I. Zn II. Na_2SO_3

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

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

11. A student determines the acetic acid concentration of a sample of distilled vinegar by titration of 25.00 mL of the vinegar with standardized sodium hydroxide solution using phenolphthalein as an indicator. Which error will give an acetic acid content for the vinegar that is too low?

(A) Some of the vinegar is spilled when being transferred from the volumetric flask to the titration flask.

(B) The NaOH solution is allowed to stand for a prolonged period after standardization and absorbs carbon dioxide from the air.

(C) The endpoint is recorded when the solution turns dark red instead of faint pink.

(D) The vinegar is diluted with distilled water in the titration flask before the NaOH solution is added.

12. Which piece of equipment would give the most precise delivery of 25.0 mL of a solution?

(A) 25-mL graduated cylinder

(B) 25-mL syringe

(C) 25-mL beaker

(D) 25-mL volumetric pipet

13. A sample of neon gas is held at 25.0 °C and 1.0 atm in a cylinder with a movable piston. Under these conditions the gas occupies 5.0 L. What volume does the gas occupy at 12.5 °C and 1.0 atm?

(A) 2.5 L **(B)** 4.8 L **(C)** 5.2 L **(D)** 10 L

14. The normal boiling points of molecular fluorine, chlorine, bromine, and iodine increase in that order. Which of the following statements accounts for this increase?

(A) The chemical reactivity decreases in that order.

(B) The London dispersion forces increase in that order.

(C) The dipole-dipole forces increase in that order.

(D) The hydrogen bonding increases in that order.

15. Quartz, SiO_2, is the most common mineral found on the surface of the earth. What is the best explanation for the fact that quartz is hard and has a high melting point?

(A) Quartz crystals are extended structures in which each atom forms strong covalent bonds with all of its neighboring atoms.

(B) Quartz crystals consist of positive and negative ions that are attracted to one another.

(C) Quartz crystals are formed under extremes of temperature and pressure.

(D) Silicon and oxygen atoms are especially hard because of their electronic structure.

16. The critical point of carbon dioxide is 304 K and 73 atm. Under which conditions is carbon dioxide a liquid?

I. 303 K and 73 atm II. 305 K and 74 atm

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

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

17. The lattice energy (energy required to separate the ions in an ionic solid) of MgO is much larger than that of LiF. What contributes the most to this difference?

(A) Mg^{2+} is a smaller ion than Li^+, and O^{2-} is a smaller ion than F^-.

(B) F is more electronegative than O, and Li is more electropositive than Mg.

(C) MgO contains doubly charged ions, while LiF contains singly charged ions.

(D) MgO contains more electrons than LiF.

18. Which best describes the bonding in Cu(s)?

(A) The copper atoms are positively charged in a sea of delocalized electrons.

(B) The copper atoms are alternately positively and negatively charged.

(C) The copper atoms form covalent bonds to adjacent copper atoms.

(D) The copper atoms form hydrogen bonds to adjacent copper atoms.

19. A sample of 54.0 g of methanol is heated from 25.0 °C to 35.0 °C. How much heat is required? The specific heat capacity of methanol is 2.48 J g^{-1} K^{-1}.

(A) 0.00459 J **(B)** 0.0747 J

(C) 1340 J **(D)** 4690 J

20. Given the standard enthalpy changes for the reactions:

$P_4(s) + 3\ O_2(g) \rightarrow P_4O_6(s)$ $\Delta H^o = -1640$ kJ mol^{-1}

$P_4(s) + 5\ O_2(g) \rightarrow P_4O_{10}(s)$ $\Delta H^o = -2940$ kJ mol^{-1}

Calculate the standard enthalpy change ΔH^o for the following reaction:

$$P_4O_6(s) + 2\ O_2(g) \rightarrow P_4O_{10}(s)$$

(A) -4.58×10^3 kJ mol^{-1} **(B)** -1.30×10^3 kJ mol^{-1}

(C) 1.79 kJ mol^{-1} **(D)** 4.82×10^6 kJ mol^{-1}

21. At what temperature is the following reaction at equilibrium when all substances are at standard pressure? Assume that entropies and enthalpies of reaction do not vary with temperature.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

Substance	ΔH^o_f, kJ mol^{-1}	S^o, J mol^{-1} K^{-1}
$PCl_3(g)$	–288.7	311.6
$Cl_2(g)$	0	223.1
$PCl_5(g)$	–374.9	364.2

(A) 506 K **(B)** 1640 K

(C) 1980 K **(D)** 4260 K

22. Given the bond dissociation enthalpies (BDE) below, what is the approximate ΔH^o_f for $H_2O(g)$?

Bond	BDE, kJ mol^{-1}	Bond	BDE, kJ mol^{-1}
H–H	432	O–O	146
O–H	467	O=O	495

(A) –934 kJ mol^{-1} **(B)** –510. kJ mol^{-1}

(C) –429 kJ mol^{-1} **(D)** –255 kJ mol^{-1}

23. Which of the following are true for a spontaneous process in a system at constant temperature and pressure?

I. $\Delta S_{sys} + \Delta S_{surr} > 0$ II. $\Delta G_{sys} < 0$

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

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

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24. What is ΔG^{o}_{f} of HOCl(g) at 298 K?.

$$H_2O(g) + Cl_2O(g) \rightleftharpoons 2\ HOCl(g)$$

$$K_{eq}\ (298\ K) = 0.089$$

(A) –6.0 kJ mol^{-1}

(B) –3.0 kJ mol^{-1}

(C) 3.0 kJ mol^{-1}

(D) It cannot be determined from the information given.

25. If elemental bromine is being formed according to the equation below at a rate of 0.056 M s^{-1}, at what rate is bromide ion being consumed?

$$5\ Br^-(aq) + BrO_3^-(aq) + 6\ H^+(aq) \rightarrow$$

$$3\ Br_2(aq) + 3\ H_2O(l)$$

(A) 0.019 M s^{-1} **(B)** 0.034 M s^{-1}

(C) 0.056 M s^{-1} **(D)** 0.093 M s^{-1}

26. Thallium-201, a radioactive isotope used to image the heart, has a half-life of 3.05 d. How long would it take for a sample of thallium-201 to decay to 18% of its original activity?

(A) 4.4 d **(B)** 6.1 d **(C)** 7.5 d **(D)** 17 d

27. For the reaction:

$$Cr(H_2O)_6^{3+}(aq) + SCN^-(aq) \rightarrow$$

$$Cr(H_2O)_5SCN^{2+}(aq) + H_2O(l)$$

The following data were collected:

$[Cr(H_2O)_6^{3+}]$, M	$[SCN^-]$, M	Rate, M hr^{-1}
0.028	0.040	8.1×10^{-6}
0.028	0.055	1.1×10^{-5}
0.037	0.055	1.5×10^{-5}

What is the rate law for the reaction?

(A) Rate = $(9.1 \times 10^{-9}\ M^{-1}\ hr^{-1})[Cr(H_2O)_6^{3+}][SCN^-]$

(B) Rate = $(7.2 \times 10^{-3}\ M^{-1}\ hr^{-1})[Cr(H_2O)_6^{3+}][SCN^-]$

(C) Rate = $(2.9 \times 10^{-4}\ hr^{-1})[Cr(H_2O)_6^{3+}]$

(D) Rate = $(3.9 \times 10^{-4}\ hr^{-1})[Cr(H_2O)_6^{3+}]$

28. In which of the following ways may a catalyst increase the rate of a reaction?

I. It may alter the rate law.

II. It may decrease the overall activation energy.

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

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

29. For an exothermic reaction, which of the following best describes the effect of increasing the temperature on the forward and reverse reactions?

(A) Both the forward and reverse rates increase, but the forward rate increases more than the reverse rate.

(B) Both the forward and reverse rates increase, but the reverse rate increases more than the forward rate.

(C) The forward rate increases while the reverse rate decreases.

(D) The reverse rate increases while the forward rate decreases.

30. The reaction of *tert*-butyl bromide with azide ion in aqueous solution is proposed to proceed by the following mechanism:

$$(CH_3)_3CBr(aq) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} (CH_3)_3C^+(aq) + Br^-(aq)$$

$$(CH_3)_3C^+(aq) + N_3^-(aq) \xrightarrow{k_2} (CH_3)_3CN_3(aq)$$

Assuming that $(CH_3)_3C^+(aq)$ achieves a steady-state concentration, but making no further assumptions about the relative magnitudes of the three rate constants, what is the rate law for this reaction?

(A) Rate = $k_1[(CH_3)_3CBr]$

(B) Rate = $k_2[(CH_3)_3CBr][N_3^-]$

(C) Rate = $\dfrac{k_1k_2[(CH_3)_3CBr][N_3^-]}{k_{-1}[Br^-]}$

(D) Rate = $\dfrac{k_1k_2[(CH_3)_3CBr][N_3^-]}{k_{-1}[Br^-] + k_2[N_3^-]}$

31. Which solution has the greatest percent ionization?

(A) 0.010 M formic acid ($K_a = 1.8 \times 10^{-4}$)

(B) 0.10 M formic acid ($K_a = 1.8 \times 10^{-4}$)

(C) 0.010 M acetic acid ($K_a = 1.8 \times 10^{-5}$)

(D) 0.10 M acetic acid ($K_a = 1.8 \times 10^{-5}$)

32. Calcium oxalate, CaC_2O_4 (M = 128.1), dissolves to the extent of 0.67 mg L^{-1}. What is its K_{sp}?

(A) 6.7×10^{-4} **(B)** 4.5×10^{-7}

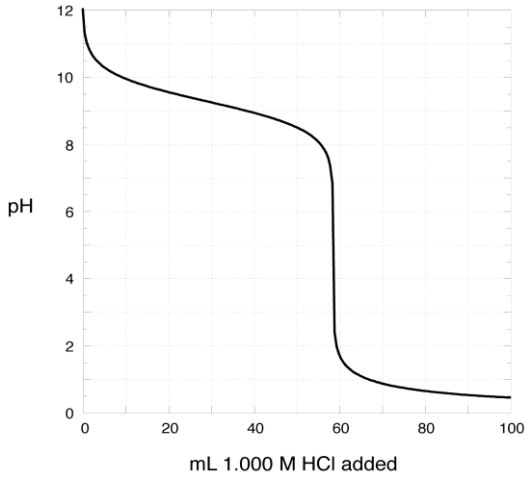
(C) 2.7×10^{-11} **(D)** 5.7×10^{-16}

33. What is the concentration of a solution of K_2CO_3 that has pH = 11.90? (For H_2CO_3, $K_{a1} = 4.2 \times 10^{-7}$, $K_{a2} = 4.8 \times 10^{-11}$.)

(A) 3.0×10^{-1} M **(B)** 2.6×10^{-2} M

(C) 7.9×10^{-3} M **(D)** 1.3×10^{-12} M

34. 1.000 g of a weak base is titrated with 1.000 M aqueous HCl to give the data shown. What is the identity of the base?



(A) Ammonia, NH_3 (pK_a of NH_4^+ = 9.3)

(B) Aniline, $C_6H_5NH_2$ (pK_a of $C_6H_5NH_3^+$ = 4.6)

(C) Hydroxylamine, NH_2OH (pK_a of NH_3OH^+ = 6.0)

(D) Trimethylamine, $(CH_3)_3N$ (pK_a of $(CH_3)_3NH^+$ = 9.8)

35. Sulfuryl chloride is in equilibrium with sulfur dioxide and chlorine gas:

$$SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$$

A system with a volume of 1.00 L is in equilibrium at a certain temperature with $p(SO_2Cl_2)$ = 1.00 bar and $p(SO_2)$ = $p(Cl_2)$ = 0.10 bar. By how much will the number of moles of SO_2Cl_2 at equilibrium change if the volume is reduced to 0.50 L?

(A) Increase 1-10% **(B)** Increase 11-50%

(C) Decrease 1-10% **(D)** Decrease 11-50%

36. Which of the following will increase $[Cl^-]$ in a saturated solution of AgCl in contact with excess solid silver chloride?

I. Addition of AgCl(*s*) II. Addition of $NH_3(aq)$

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

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

37. Which is formed at the cathode during the electrolysis of aqueous AgF?

(A) Ag(*s*) **(B)** $H_2(g)$ **(C)** $O_2(g)$ **(D)** $F_2(g)$

38. In which of the following substances is chlorine in the lowest oxidation state?

(A) Cl_2 **(B)** KCl **(C)** KClO **(D)** $KClO_4$

39. When the following reaction is balanced, what is the ratio of coefficients of $H^+(aq)$ to $NO(g)$?

$$Cu(s) + H^+(aq) + NO_3^-(aq) \rightarrow NO(g) + H_2O(l) + Cu^{2+}(aq)$$

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

40. What is E^o for the following reaction?

$$2\ Al^{3+}(aq) + 3\ Zn(s) \rightarrow 2\ Al(s) + 3\ Zn^{2+}(aq)$$

Half-Reaction	E^o, V
$Al^{3+}(aq) + 3\ e^- \rightarrow Al(s)$	–1.66
$Zn^{2+}(aq) + 2\ e^- \rightarrow Zn(s)$	–0.76

(A) –1.04 V **(B)** –0.90 V

(C) 0.90 V **(D)** 1.04 V

41. Electrolysis of 1.00 g of a copper(II) salt required passage of 0.100 A of current for 123 min for complete deposition of all the copper metal. What is the copper salt?

(A) $CuCl_2$, M = 134.5 **(B)** $CuBr_2$, M = 223.4

(C) $Cu(NO_3)_2$, M = 187.6 **(D)** $Cu(ClO_4)_2$, M = 262.5

42. What is the K_{sp} of Hg_2Cl_2 at 298 K?

Half-Reaction	E^o, V (at 298 K)
$Hg_2^{2+} + 2e^- \rightarrow 2\ Hg(l)$	+0.80
$Hg_2Cl_2(s) + 2e^- \rightarrow 2\ Hg(l) + 2\ Cl^-(aq)$	+0.31

(A) 2.6×10^{-17} **(B)** 3.3×10^{-11}

(C) 5.1×10^{-9} **(D)** 5.7×10^{-6}

43. How many total orbitals are there with principal quantum number n = 4?

(A) 1 **(B)** 4 **(C)** 9 **(D)** 16

44. Addition of an electron to a gas-phase Si atom results in the release of more energy than addition of an electron to a gas-phase P atom. What is the best explanation for their relative electron affinities?

(A) The electron added to Si experiences less electron-electron repulsion than the electron added to P.

(B) The electron added to Si enters a lower-energy subshell than the electron added to P.

(C) Si is more electronegative than P.

(D) Si is smaller than P.

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45. The wavelength of one of the spectral lines of helium is 492 nm. What is the energy of a photon with this wavelength?

(A) 3.26×10^{-40} J **(B)** 3.26×10^{-31} J

(C) 4.04×10^{-28} J **(D)** 4.04×10^{-19} J

46. Which of the following gas-phase ions has the largest number of unpaired electrons in its ground state?

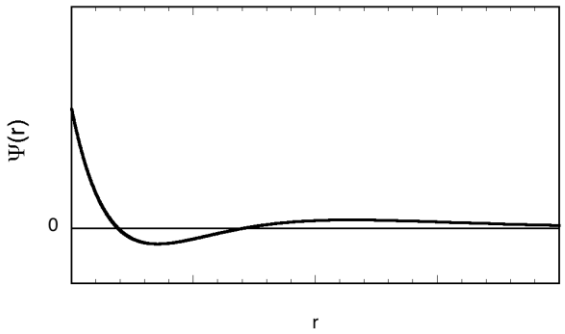
(A) Cr^{3+} **(B)** Co^{3+} **(C)** Ni^{2+} **(D)** Cu^{2+}

47. ^{52}Mn undergoes radioactive decay to give ^{52}Cr by what decay mode?

(A) Alpha emission **(B)** Beta emission

(C) Positron emission **(D)** Gamma emission

48. An orbital has the radial wavefunction shown below. What orbital is it?



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

49. Which molecule has a dipole moment of zero?

(A) CO **(B)** CO_2 **(C)** CH_2O **(D)** CH_3OH

50. What is the geometry of SF_4?

(A) Tetrahedral

(B) Square planar

(C) See-saw

(D) Trigonal monopyramidal

51. How many σ and π bonds are in 1,3-butadiene, $H_2C{=}CH{-}CH{=}CH_2$?

(A) 7 σ and 2 π bonds **(B)** 2 σ and 7 π bonds

(C) 9 σ and 2 π bonds **(D)** 2 σ and 9 π bonds

52. What is the formal charge on the central nitrogen in the Lewis structure of N_2O?

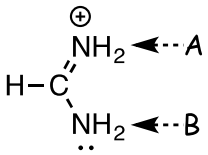
(A) 0

(B) +1

(C) –1

(D) 0 in some resonance structures, –1 in other resonance structures

53. Shown below is a Lewis structure of the formamidinium ion. What geometry is exhibited by the two nitrogens in the formamidinium ion?



	Geometry at **A**	Geometry at **B**
(A)	trigonal planar	trigonal planar
(B)	trigonal planar	trigonal pyramidal
(C)	trigonal pyramidal	trigonal planar
(D)	trigonal pyramidal	trigonal pyramidal

54. How many unpaired electrons are in the superoxide ion, O_2^-?

(A) Zero **(B)** One **(C)** Two **(D)** Three

55. What is the relationship between the following two molecules?

(A) Structural isomers **(B)** Geometric isomers

(C) Enantiomers **(D)** Identical

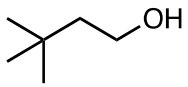
56. What is the role of hydroxide ion in the reaction below?

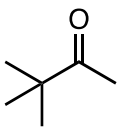
$CH_3CH_2CH_2CH_2Br + OH^- \rightarrow CH_3CH_2CH_2CH_2OH + Br^-$

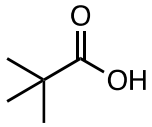
(A) Oxidizing agent **(B)** Lewis acid

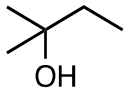
(C) Catalyst **(D)** Nucleophile

57. Which compound reacts readily with Cr(VI) reagents?

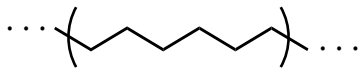
(A) 

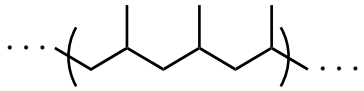
(B) 

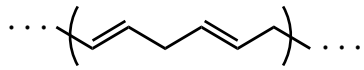
(C) 

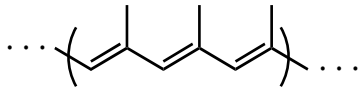
(D) 

58. What is the structure of polypropylene, formed by the polymerization of propene (CH_2=$CHCH_3$)?

(A) 

(B) 

(C) 

(D) 

59. The sequence of amino acids in a protein is known as its

(A) primary structure. **(B)** secondary structure.

(C) tertiary structure. **(D)** quaternary structure.

60. Molecules from which class of biopolymers can react with water, in the presence of suitable enzymes, to form smaller examples of that class of biopolymers?

I. Proteins II. Polysaccharides

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

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

END OF TEST

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Olympiad 2017
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KEY

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

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