

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. Which anion forms the smallest number of insoluble salts?
 (A) Cl^- (B) NO_3^- (C) CO_3^{2-} (D) SO_4^{2-}

2. Which piece of apparatus can measure a volume of 25.0 mL most precisely?
 (A) 25 mL beaker (B) 25 mL conical flask
 (C) 25 mL graduated cylinder (D) 25 mL pipet

3. How many significant figures should be reported in the answer to the calculation (Assume all numbers are experimentally determined.)

$$\frac{12.501 \times 3.52}{0.0042} + 6.044$$

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

4. Five pellets of a metal have a total mass of 1.25 g and a total volume of 0.278 mL. What is the density of the metal in $\text{g}\cdot\text{mL}^{-1}$?

- (A) 0.348 (B) 0.900 (C) 4.50 (D) 22.5

5. What is the color of the flame test for sodium?

- (A) green (B) red
 (C) violet (D) yellow

6. When is it acceptable to eat in a chemistry laboratory?

- (A) Anytime when a person is not doing an experiment.
 (B) Whenever there are no hazardous chemicals out.
 (C) If it is necessary to do so in order to keep another appointment.
 (D) Never.

7. Selenium (Se) is similar to sulfur in its properties and francium (Fr) is an alkali metal. What is the formula for francium selenite?

- (A) FrSeO_2 (B) Fr_2SeO_4
 (C) Fr_2SeO_3 (D) $\text{Fr}_2\text{Se}_2\text{O}_3$

8. Calculate the mass percentage of nitrogen in hydrazinium sulfate ($\text{N}_2\text{H}_5)_2\text{SO}_4$.

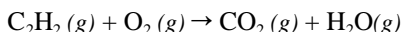
Molar mass, $\text{g}\cdot\text{mol}^{-1}$	
$(\text{N}_2\text{H}_5)_2\text{SO}_4$	162.2

- (A) 10.8 (B) 17.3 (C) 34.5 (D) 51.2

9. How many ozone molecules are in 3.20 g of O_3 ?

- (A) 4.0×10^{22} (B) 6.0×10^{22}
 (C) 1.2×10^{23} (D) 6.0×10^{23}

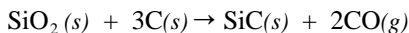
10. Acetylene, C_2H_2 , reacts with oxygen according to the unbalanced equation:



What is the $\text{O}_2/\text{C}_2\text{H}_2$ ratio when this equation is correctly balanced?

- (A) 2/1 (B) 3/1 (C) 4/1 (D) 5/2

11. Silicon carbide, SiC, is produced by heating SiO_2 and C to high temperatures according to the equation:



How many grams of SiC could be formed by reacting 2.00 g of SiO_2 and 2.00 g of C?

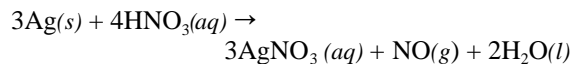
- (A) 1.33 (B) 2.26 (C) 3.59 (D) 4.00

12. A 7.66 g sample of hydrated sodium sulfate, $\text{Na}_2\text{SO}_4 \cdot x\text{H}_2\text{O}$, forms 4.06 g of anhydrous Na_2SO_4 . What is the value of x?

Molar mass, $\text{g}\cdot\text{mol}^{-1}$	
Na_2SO_4	142

- (A) 0.2 (B) 3.6 (C) 5 (D) 7

13. Silver metal reacts with nitric acid according to the equation:



What volume of 1.15 M $\text{HNO}_3(aq)$ is required to react with 0.784 g of silver?

- (A) 4.74 mL (B) 6.32 mL
 (C) 8.43 mL (D) 25.3 mL

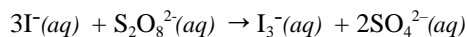
14. Which solute produces the highest boiling point in a 0.15 m aqueous solution?

- (A) CaCl_2 (B) NaBr (C) CuSO_4 (D) CH_3OH

29. Which is constant for different reactant concentrations in a first-order reaction?

- (A) The time required for the concentration of reactants to drop below 0.001 M.
 (B) The time required for one-half of reactants to disappear.
 (C) The rate of disappearance of reactants in $\text{mol}\cdot\text{L}^{-1}\cdot\text{time}^{-1}$.
 (D) The rate of formation of products in $\text{mol}\cdot\text{L}^{-1}\cdot\text{time}^{-1}$.

30. The reaction,



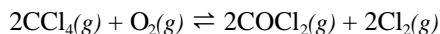
yields the kinetic data in the table.

$[\text{I}^{-}]_0 (\text{mol}\cdot\text{L}^{-1})$	$[\text{S}_2\text{O}_8^{2-}]_0 (\text{mol}\cdot\text{L}^{-1})$	Relative Rate
0.001	0.001	1
0.002	0.001	2
0.002	0.002	4

What is the rate equation?

- (A) $\text{Rate} = k[\text{I}^{-}][\text{S}_2\text{O}_8^{2-}]$ (B) $\text{Rate} = k[\text{I}^{-}]^2[\text{S}_2\text{O}_8^{2-}]$
 (C) $\text{Rate} = k[\text{I}^{-}]^3[\text{S}_2\text{O}_8^{2-}]$ (D) $\text{Rate} = k[\text{I}^{-}]^2[\text{S}_2\text{O}_8^{2-}]^2$

31. For the reaction,



what is the equilibrium expression, K_c ?

- (A) $K_c = \frac{[\text{COCl}_2][\text{Cl}_2]}{[\text{CCl}_4][\text{O}_2]}$ (B) $K_c = \frac{2[\text{COCl}_2][\text{Cl}_2]}{[\text{CCl}_4][\text{O}_2]}$
 (C) $K_c = \frac{[\text{COCl}_2][\text{Cl}_2]^2}{[\text{CCl}_4][\text{O}_2]}$ (D) $K_c = \frac{[\text{COCl}_2]^2[\text{Cl}_2]^2}{[\text{CCl}_4]^2[\text{O}_2]}$

32. For the reaction,



Which change(s) will increase the fraction of $\text{SO}_3(\text{g})$ in the equilibrium mixture?

- Increasing the pressure
- Increasing the temperature
- Adding a catalyst

- (A) 1 only (B) 3 only
 (C) 1 and 3 only (D) 1, 2 and 3

33. What is the $[\text{H}^{+}]$ in a 0.10 M solution of ascorbic acid, $\text{C}_6\text{H}_8\text{O}_6$?

K_a	
$\text{C}_6\text{H}_8\text{O}_6$	8.0×10^{-5}

- (A) $8.0 \times 10^{-6} \text{ M}$ (B) $2.8 \times 10^{-3} \text{ M}$
 (C) $4.0 \times 10^{-3} \text{ M}$ (D) $5.3 \times 10^{-3} \text{ M}$

34. A 0.10 M solution of which salt is the most acidic?

- (A) $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$ (B) NaCN
 (C) KNO_3 (D) AlCl_3

35. A student is asked to prepare a buffer solution with a pH of 4.00. This can be accomplished by using a solution containing which of the following?

K_a	
HNO_2	4.5×10^{-4}
HCN	4.9×10^{-10}

- (A) HNO_2 only (B) HCN only
 (C) HNO_2 and NaNO_2 (D) HCN and NaCN

36. A saturated solution of which compound has the lowest $[\text{Ca}^{2+}]$?

K_{sp}	
CaF_2	4.0×10^{-11}
CaCO_3	8.7×10^{-9}
$\text{Ca}(\text{OH})_2$	8.0×10^{-6}
CaSO_4	2.4×10^{-5}

- (A) CaF_2 (B) CaCO_3 (C) $\text{Ca}(\text{OH})_2$ (D) CaSO_4

37. Which reaction occurs at the cathode during the electrolysis of an aqueous solution of KCl ?

- (A) $\text{K}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{K}(\text{s})$
 (B) $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^{-} \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^{-}(\text{aq})$
 (C) $2\text{Cl}^{-}(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^{-}$
 (D) $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^{+}(\text{aq}) + 4\text{e}^{-}$

38. Correct statements about a voltaic (galvanic) cell include which of the following?

- Oxidation occurs at the anode.
- Electrons flow from the cathode to the anode.

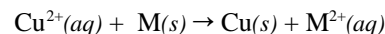
- (A) 1 only (B) 2 only
 (C) Both 1 and 2 (D) Neither 1 nor 2

39. $\text{MnO}_4^{-} + \text{NO}_2^{-} + \text{H}^{+} \rightarrow \text{Mn}^{2+} + \text{NO}_3^{-} + \text{H}_2\text{O}$

When this equation is balanced correctly with the smallest integer coefficients, what is the coefficient for H^{+} ?

- (A) 1 (B) 6 (C) 8 (D) 16

40. An electrochemical cell constructed for the reaction:



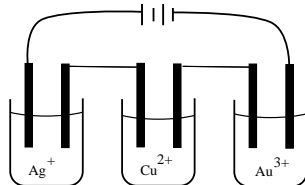
has an $E^\circ = 0.75 \text{ V}$. The standard reduction potential for $\text{Cu}^{2+}(\text{aq})$ is 0.34 V. What is the standard reduction potential for $\text{M}^{2+}(\text{aq})$?

- (A) 1.09 V (B) 0.410 V
 (C) -0.410 V (D) -1.09 V

41. In which case does chromium undergo reduction?

- (A) $\text{CrO}_3 \rightarrow \text{CrOF}_3$ (B) $\text{Cr}^{3+} \rightarrow \text{Cr}(\text{OH})_4^-$
 (C) $2\text{CrO}_4^{2-} \rightarrow \text{Cr}_2\text{O}_7^{2-}$ (D) $\text{Cr}^{3+} \rightarrow \text{CrO}_4^{2-}$

42. 1.0 M aqueous solutions of AgNO_3 , $\text{Cu}(\text{NO}_3)_2$ and $\text{Au}(\text{NO}_3)_3$ are electrolyzed in the apparatus shown, so the same amount of electricity passes through each solution. If 0.10 moles of solid Cu are formed how many moles of Ag and Au are formed?



- (A) 0.10 moles Ag, 0.10 moles Au
 (B) 0.05 moles Ag, 0.075 moles Au
 (C) 0.05 moles Ag, 0.15 moles Au
 (D) 0.20 moles Ag, 0.067 moles Au

43. In a hydrogen atom, which transition produces a photon with the highest energy?

- (A) $n = 3 \rightarrow n = 1$ (B) $n = 5 \rightarrow n = 3$
 (C) $n = 12 \rightarrow n = 10$ (D) $n = 22 \rightarrow n = 20$

44. How many orbitals in a ground state oxygen atom are completely filled?

- (A) 1 (B) 2 (C) 3 (D) 4

45. Which atom has the smallest first ionization energy?

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

46. The electron configuration of a cobalt atom is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$.

How many unpaired electrons are present in a gaseous Co^{3+} ion in its ground state?

- (A) 6 (B) 4 (C) 2 (D) 0

47. When the atoms; P ($Z = 15$), S ($Z = 16$) and As ($Z = 33$), are arranged in order of increasing radius, what is the correct order?

- (A) P, S, As (B) As, S, P
 (C) S, P, As (D) P, As, S

48. The oxide of which element is the most ionic?

- (A) Al (B) B (C) C (D) Si

49. All of the following lists include at least one ionic compound EXCEPT

- (A) NO_2 , NaNO_2 , KNO_3 (B) CF_4 , CaF_2 , HF
 (C) NaCl , MgCl_2 , SCl_2 (D) H_2S , SO_2 , SF_6

50. Which species below has the same general shape as NH_3 ?

- (A) SO_3^{2-} (B) CO_3^{2-} (C) NO_3^- (D) SO_3

51. When forming covalent bonds, which atom can have more than eight valence electrons?

- (A) H (B) N (C) F (D) Cl

52. Which diatomic molecule has the shortest bond length?

- (A) N_2 (B) O_2 (C) F_2 (D) S_2

53. Which species is nonpolar?

- (A) HCl (B) OCl_2 (C) NCl_3 (D) CCl_4

54. In which species are all the carbon atoms considered to be sp^2 hybridized?

- (A) C_2H_2 (B) C_2H_4 (C) C_3H_8 (D) C_4H_{10}

55. Which formula can be used to represent an alkynes?

- (A) $\text{C}_n\text{H}_{2n-2}$ (B) C_nH_{2n}
 (C) $\text{C}_n\text{H}_{2n+2}$ (D) $\text{C}_n\text{H}_{2n+4}$

56. How many different structural isomers exist for dichloropropane, $\text{C}_3\text{H}_6\text{Cl}_2$?

- (A) 4 (B) 5 (C) 6
 (D) some other number

57. All of the formulas below correspond to stable compounds EXCEPT

- (A) CH_2O (B) CH_2O_2
 (C) CH_3O (D) CH_4O

58. Which of the compounds shown are isomers?

- | | |
|---|---|
| 1 | $\text{CH}_3\text{CH}_2\text{OCH}_3$ |
| 2 | $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$ |
| 3 | $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ |
| 4 | $\text{CH}_2=\text{CHOCH}_3$ |

- (A) 1 and 3 (B) 1 and 2
 (C) 2 and 3 (D) 1 and 4

59. Which functional group is present in CH_3COOH ?

- (A) aldehyde (B) carboxylic acid
 (C) alcohol (D) hydroperoxide

60. How many sigma bonds does a molecule of ethene have?

- (A) 1 (B) 4 (C) 5 (D) 7

END OF TEST

Olympiad Local Section Exam 2003 KEY

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