NATIONAL Science Bee

National Championship Science Chemistry Exam

Name _____

School _____

Grade _____

Email address _____

Instructions – Circle the correct answer or leave it blank. Correct answers are worth 2 points. Incorrect answers are worth −1 point. Questions left blank are worth 0 points.

1. Molecules can be described as?
   A. mixtures of two or more pure substances.
   B. mixtures of two or more elements that have a specific ratio between components.
   C. two or more atoms chemically joined together.
   D. homogeneous mixtures.

2. The statement, "In a chemical reaction, matter is neither created nor destroyed" is called?
   A. the Law of Conservation of Mass.
   B. Dalton's Atomic Theory.
   C. the Scientific Method.
   D. the Law of Multiple Proportions.

3. Which of the following statements about crystalline and amorphous solids is TRUE?
   A. A crystalline solid is composed of atoms or molecules arranged with long-range repeating order.
   B. An example of a crystalline solid is glass.
   C. An example of an amorphous solid is table salt (NaCl).
   D. An amorphous solid is composed of atoms or molecules with a majority of its volume empty.

4. All of the following are SI base units of measurement, EXCEPT
   A. meter.
   B. gram.
   C. second.
   D. kelvin.

5. Which of the following is an example of the law of multiple proportions?
   A. A sample of chlorine is found to contain three times as much Cl-35 as Cl-37.
   B. Two different compounds formed from carbon and oxygen have the following mass ratios: 1.33 g O: 1 g C and 2.66 g O: 1 g C.
   C. Two different samples of table salt are found to have the same ratio of sodium to chlorine.
   D. The atomic mass of bromine is found to be 79.90 amu.

6. Identify the equipment that Millikan utilized to do his research.
   A. light bulb
   B. oscilloscope
   C. oil atomizer, light source, microscope
   D. electromagnetic field generator

7. Predict the charge that an aluminum ion would have.
   A. 1+
   B. 1–
   C. 2+
   D. 3+

8. Give a possible molecular formula for the empirical formula of C_3H_5ClO.
   A. $C_5H_{10}Cl_2O_2$
   B. $C_6H_{10}Cl_2O_2$
   C. $C_6H_{10}O_2$
   D. $C_6H_{12}Cl_2O_2$

9. Give the name for $KMnO_4$.
   A. potassium manganese tetraoxide
   B. potassium manganate
   C. potassium permanganate
   D. potassium permagnesium

10. Write a balanced equation to show the reaction of sulfurous acid with lithium hydroxide to form water and lithium sulfite.
   A. $H_2SO_4(aq) + LiOH(aq) \rightarrow H_2O(l) + Li_2SO_4(aq)$
   B. $H_2SO_3(aq) + 2\ LiOH(aq) \rightarrow 2\ H_2O(l) + Li_2SO_3(aq)$
   C. $HSO_3(aq) + LiOH(aq) \rightarrow H_2O(l) + LiSO_3(aq)$
   D. $HSO_4(aq) + LiOH(aq) \rightarrow H_2O(l) + LiSO_4(aq)$

11. Write a balanced equation to show the reaction of aqueous aluminum acetate with aqueous ammonium phosphate to form solid aluminum phosphate and aqueous ammonium acetate.
   A. $Al(C_2H_3O_2)_2(aq) + (NH_4)_2PO_4(aq) \rightarrow AlPO_4(s) + 2\ NH_4C_2H_3O_2(aq)$
   B. $Al(C_2H_3O_2)_2(aq) + (NH_3)_2PO_4(aq) \rightarrow AlPO_4(s) + 2\ NH_3C_2H_3O_2(aq)$
   C. $Al(CO_3)_2(aq) + (NH_3)_2PO_4(aq) \rightarrow AlPO_4(s) + 2\ NH_3CO_3(aq)$
   D. $Al(C_2H_3O_2)_3(aq) + (NH_4)_3PO_4(aq) \rightarrow AlPO_4(s) + 3\ NH_4C_2H_3O_2(aq)$

12. Which of the following contains BOTH ionic and covalent bonds?
   A. BaF_2
   B. Cl_2
   C. $MgSO_4$
   D. SF_6

13. Which of the following is the correct chemical formula for a molecule of chlorine?
   A. Cl
   B. Cl^-
   C. Cl^+
   D. Cl_2

14. Write the name for $Mg_3(PO_4)_2$.
   A. magnesium(III) phosphite
   B. magnesium(II) phosphite
   C. magnesium phosphate
   D. trimagnesium phosphorustetraoxide

15. Identify an ether.
   A. $CH_3CH_2OCH_2CH_3$
   B. CH_3CH_2Br
   C. $CH_3CH_2PH_2$
   D. CH_3COOH

16. Identify ammonia.
   A. strong electrolyte, strong base
   B. strong electrolyte, weak base
   C. weak electrolyte, strong base
   D. weak electrolyte, weak base

17. Choose the statement below that is TRUE.
   A. A weak acid solution consists of mostly nonionized acid molecules.
   B. The term "strong electrolyte" means that the substance is extremely reactive.
   C. A strong acid solution consists of only partially ionized acid molecules.
   D. The term "weak electrolyte" means that the substance is inert.

18. Give the complete ionic equation for the reaction (if any) that occurs when aqueous solutions of lithium sulfide and copper(II) nitrate are mixed.
    A. $2\ Li^+(aq) + S^{2-}(aq) + Cu^{2+}(aq) + 2\ NO_3^-(aq) \rightarrow Cu^{2+}(aq) + S^{2-}(aq) + 2\ Li^+(aq) + 2\ NO_3^-(aq)$
    B. $2\ Li^+(aq) + S^{2-}(aq) + Cu^{2+}(aq) + 2\ NO_3^-(aq) \rightarrow CuS(s) + 2\ LiNO3(s)$
    C. $2\ Li^+(aq) + S^{2-}(aq) + Cu^{2+}(aq) + 2\ NO_3^-(aq) \rightarrow Cu^{2+}(aq) + S^{2-}(aq) + 2\ LiNO_3(s)$
    D. $2\ Li^+(aq) + S^{2-}(aq) + Cu^{2+}(aq) + 2\ NO_3^-(aq) \rightarrow CuS(s) + 2\ Li^+(aq) + 2\ NO_3^-(aq)$

19. Choose the reaction that represents the combustion of $C_6H_{12}O_2$.
    A. $C_6H_{12}O_2(l) + 8\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(g)$
    B. $Mg(s) + C_6H_{12}O_2(l) \rightarrow MgC_6H_{12}O_2(aq)$
    C. $6\ C(s) + 6\ H_2(g) + O_2(g) \rightarrow C_6H_{12}O_2(l)$
    D. $C_6H_{12}O_2(l) \rightarrow 6\ C(s) + 6\ H_2(g) + O_2(g)$

20. Determine the oxidation state of P in PO_3^{3-}.
    A. +3
    B. +6
    C. +2
    D. 0

21. What element is undergoing oxidation (if any) in the following reaction?

$$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$$

    A. O
    B. H
    C. C
    D. both C and H

22. Determine the oxidizing agent in the following reaction.

$$Ni(s) + 2\ AgClO_4(aq) \rightarrow Ni(ClO_4)_2(aq) + 2\ Ag(s)$$

    A. Ag
    B. Ni
    C. Cl
    D. O

23. Which of the following solutions will have the highest concentration of fluoride ions?
    A. 0.10 M KF
    B. 0.10 M SrF_2
    C. 0.10 M AlF_3
    D. 0.05 M CaF_2

24. Identify an ethanol solution.
    A. weak electrolyte, weak base
    B. strong electrolyte, strong acid
    C. strong electrolyte, strong base
    D. nonelectrolyte

25. How many of the following compounds are soluble in water?

$Pb(OH)_2$ $LiNO_3$ NH_4Br K_2S

    A. 0
    B. 2
    C. 3
    D. 4

26. Identify the polyprotic acid.
    A. H_3PO_4
    B. HCl
    C. NaOH
    D. $Ba(OH)_2$

27. The total pressure of a gas mixture is the sum of the partial pressure of its components is known as?
    A. Ideal Gas Law.
    B. Charles's Law.
    C. Boyle's Law.
    D. Dalton's Law.

28. Which statement is TRUE about kinetic molecular theory?
    A. A single particle does not move in a straight line.
    B. The size of the particle is large compared to the volume.
    C. The collisions of particles with one another is completely elastic.
    D. The average kinetic energy of a particle is not proportional to the temperature.

29. What is the oxidation number of chlorine in NaCl?
    A. -2
    B. -1
    C. 0
    D. +1

30. Which of the following describes a salt bridge?
    A. A pathway composed of salt water that ions pass through.
    B. A pathway in which no ions flow.
    C. A pathway between the cathode and anode in which ions are oxidized.
    D. A pathway by which counterions can flow between the half-cells without the solutions in the half-cell totally mixing.

31. The rate of effusion of two different gasses is known as?
    A. Avogadro's Law.
    B. Graham's Law.
    C. Charles's Law.
    D. Boyle's Law.

32. Which of the following signs on q and w represent a system that is doing work on the surroundings, as well as losing heat to the surroundings?
    A. q = –, w = –
    B. q = +, w = +
    C. q = –, w = +
    D. q = +, w = –

33. For ΔE_{sys} to always be –, what must be TRUE?
    A. q = w
    B. +q > –w
    C. +w > –q
    D. –w > +q

34. Which statement is FALSE?
    A. An exothermic reaction gives off heat to the surroundings.
    B. Enthalpy is the sum of a system's internal energy and the product of pressure and volume.
    C. ΔErxn is a measure of heat.
    D. ΔHrxn is the heat of reaction.

35. Which of the following is TRUE if ΔEsys = –100 J?
    A. The system is gaining 100 J, while the surroundings are losing 100 J.
    B. The system is losing 100 J, while the surroundings are gaining 100 J.
    C. Both the system and the surroundings are gaining 100 J.
    D. Both the system and the surroundings are losing 100 J.

36. Which of the following processes is exothermic?
    A. a candle flame
    B. melting of ice
    C. the chemical reaction in a "cold pack" often used to treat injuries
    D. the vaporization of water

37. Identify the compound that is used to treat victims of heavy metal poisoning.
    A. KCN
    B. CO
    C. EDTA
    D. carbonic anhydrase

38. Identify the ion that is responsible for the red color of rubies.
    A. Cr^{6+}
    B. Cr^{5+}
    C. Cr^{4+}
    D. Cr^{3+}

39. _____ is a soft-white metal that has been found as a contaminant in crude oil.
    A. Vanadium
    B. Gold
    C. Silver
    D. Mercury

40. Identify the element with the highest thermal conductivity.
    A. copper
    B. vanadium
    C. silver
    D. iron

41. Identify the substances which contain a high concentration of a specific mineral.
    A. slag
    B. minerals
    C. ores
    D. gangue

42. Chromates are strong
    A. oxidizers.
    B. bases.
    C. acids.
    D. metals.

43. Identify the ferromagnetic elements.
    A. cobalt
    B. iron
    C. nickel
    D. all of the above

44. Galvanizing is when an object is dipped into a molten bath of
    A. magnesium.
    B. lithium.
    C. zinc.
    D. sodium.

45. Identify a nonmetal.
    A. P
    B. Ca
    C. Pd
    D. Ni

46. Which of the following statements is TRUE?
    A. Boron oxide, when added to silicon oxide glass, forms a more heat stable glass called Pyrex.
    B. Boron most commonly forms compounds that fulfill the octet rule.
    C. Boron forms fairly weak bonds with oxygen, due to their large electronegativity difference.
    D. Boron trichloride is an example of a strong Lewis base.

47. Determine the oxidation state of carbon in the ionic carbide, CaC2.
    A. –2
    B. +4
    C. –1
    D. +1

48. Identify baking powder.
    A. lithium bicarbonate
    B. sodium bicarbonate and an acid
    C. magnesium carbonate and a base
    D. magnesium oxide

49. Determine the oxidation state of phosphorus in $P_2O_7^{4-}$.
    A. +5
    B. +4
    C. +3
    D. +7

50. Nonsuperimposable mirror images are called.
    A. structural isomers.
    B. achiral.
    C. diastereomers.
    D. enantiomers.

51. Molecules with the same formula in which the atoms have a different connectivity are called
    A. structural isomers.
    B. achiral.
    C. diastereomers.
    D. enantiomers.

52. An equimolar mixture of two optical isomers is called
    A. an achiral molecule.
    B. a diastereomer.
    C. an enantiomer.
    D. a racemic mixture.

53. Identify the alkane with the highest boiling point.
    A. pentane
    B. butane
    C. ethane
    D. methane

54. Write a balanced chemical reaction to represent the combustion of pentane.
    A. $CH_3CH_2CH_2CH_2CH_3 + 8\ O_2 \rightarrow 5\ CO_2 + 6\ H_2O$
    B. $CH_3CH_2CH_3 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$
    C. $CH_3CH_2CH_3 + H_2 \rightarrow CH_4 + C_2H_6$
    D. $CH_3CH_2CH_2CH_2CH_3 + H_2 \rightarrow CH_4 + 2\ C_2H_6$

55. Identify the alcohol in rubbing alcohol.
    A. 2-pentanol
    B. isopropyl alcohol
    C. methanol
    D. 1-butanol

56. Identify the scientist(s) that were awarded the Nobel Prize in physics for the discovery of radioactivity in 1903.
    A. Johannes Geiger, Marie Curie
    B. Albert Einstein
    C. Antoine-Henri Becquerel, Marie Curie, Pierre Curie
    D. Ernest Rutherford, Johannes Geiger

57. Identify the elements discovered by Marie Curie.
    A. polonium and radium
    B. radium and cesium
    C. argon and xenon
    D. radon and xenon

58. Write a nuclear equation for the alpha decay of Am.
    A. $Am \rightarrow He + Np$
    B. $Am \rightarrow He + Bk$
    C. $Am \rightarrow e + Cm$

D. $Am \rightarrow e + Pu$

59. Identify the instrument(s) used to detect radiation.
    A. film-badge dosimeter
    B. Geiger-Muller counter
    C. scintillation counter
    D. all of the above

60. Identify the technique used to predict the age of the Shroud of Turin.
    A. uranium-238 to lead-206
    B. potassium-40 to argon-40
    C. carbon-14 to nitrogen-14
    D. none of the above

61. Define mass defect.
    A. the difference in mass between an atom and the sum of its separate components
    B. an atom with too many neutrons
    C. the difference in mass between a radioactive atom and a nonradioactive atom
    D. energy released in a radioactive reaction

62. Give the conditions for nuclear fusion.
    A. catalyst
    B. low temperature
    C. low pressure
    D. high temperature

63. What element is being <u>reduced</u> in the following redox reaction?

$$MnO_4^-(aq) + H_2C_2O_4(aq) \rightarrow Mn^{2+}(aq) + CO_2(g)$$

    A. C
    B. O
    C. Mn
    D. H

64. In a voltaic cell, the anode is defined as
    A. a metal contact.
    B. the more positively charged electrode.
    C. the positive terminal of the power source.
    D. the more negatively charged electrode.

65. Identify the location of oxidation in an electrochemical cell.
    A. the anode
    B. the cathode
    C. the electrode
    D. the salt bridge

66. Identify the characteristics of a spontaneous reaction.
    A. $\Delta G° < 0$
    B. $\Delta E°cell > 0$
    C. $K > 1$
    D. all of the above

67. Give the characteristic of a first-order reaction having only one reactant.
    A. The rate of the reaction is proportional to the square of the concentration of the reactant.
    B. The rate of the reaction is proportional to the square root of the concentration of the reactant.
    C. The rate of the reaction is proportional to the natural logarithm of the concentration of the reactant.
    D. The rate of the reaction is directly proportional to the concentration of the reactant.

68. What is the overall order of the following reaction, given the rate law?

$$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g) \quad Rate = k[NO][O_3]$$

    A. 1st order
    B. 2nd order
    C. 3rd order
    D. 0 order

69. What data should be plotted to show that experimental concentration data fits a first-order reaction?
    A. 1/[reactant] vs. time
    B. [reactant] vs. time
    C. ln[reactant] vs. time
    D. ln(k) vs. 1/T

70. For a reaction, what generally happens if the temperature is increased?
    A. A decrease in k occurs, which results in a slower rate.
    B. An increase in k occurs, which results in a faster rate.
    C. An increase in k occurs, which results in a slower rate.
    D. There is no change with k or the rate.

71. Identify the rate-determining step.
    A. the slowest step
    B. the faster step
    C. the fast step

D. always the last step

72. Identify the thinnest known material.
    A. buckyball
    B. diamond
    C. graphene
    D. fullerene

73. Identify the technique that determines the arrangement of atoms and measures the distance between them.
    A. x-ray diffraction
    B. ultraviolet
    C. nuclear magnetic resonance
    D. infrared

74. When two waves interact with the crests of one aligning with the troughs of the other is called
    A. complimentary interference.
    B. destructive interference.
    C. opposing interference.
    D. constructive interference.

75. Define buffer capacity.
    A. Buffer capacity is the amount of acid or base that can be added to a buffer without destroying its effectiveness.
    B. Buffer capacity is the amount of acid that can be added until all of the base is used up.
    C. Buffer capacity is the amount of base that can be added until all of the acid is used up.
    D. Buffer capacity is the amount of acid that can be added until all of the acid is used up.

Chemistry Answer Key:

1) C
2) A
3) A
4) B
5) B
6) C
7) D
8) B
9) C
10) B
11) D
12) C
13) D
14) C
15) A
16) D
17) A
18) D
19) A
20) A
21) C
22) A
23) C
24) D
25) D
26) A
27) D
28) C
29) D
30) D
31) B
32) A
33) A
34) C
35) B
36) A
37) C
38) D
39) A
40) C
41) C
42) A
43) D
44) C
45) A
46) A
47) C
48) B
49) A
50) D
51) A
52) D
53) A
54) A
55) A
56) C
57) A
58) A
59) D
60) C
61) A
62) D
63) C
64) D
65) A
66) D
67) D
68) B
69) C
70) B
71) A
72) C
73) A
74) B
75) A