North Carolina Test of Chemistry

Form A

Public Schools of North Carolina
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State Board of Education
Department of Public Instruction
Division of Accountability Services/North Carolina Testing Program
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1. How many protons and electrons are in a $^{64}_{29}\text{Cu}^{2+}$ ion?
   A  27 protons, 29 electrons
   B  27 protons, 31 electrons
   C  29 protons, 27 electrons
   D  29 protons, 31 electrons

2. What is the name of the compound with the chemical formula CrCl$_3$?
   A  chromium tetrachloride
   B  chromium trichloride
   C  chromium(II) chloride
   D  chromium(III) chloride

3. If two oxygen atoms combine to make a molecule, what type of bond will they form?
   A  an ionic bond
   B  a hydrogen bond
   C  a double covalent bond
   D  a metallic bond

4. Why did most of the alpha particles go straight through the gold foil in Rutherford’s experiment?
   A  Most of an atom is empty space.
   B  Alpha particles are positively charged.
   C  Alpha particles move with high velocity.
   D  The center of an atom is positively charged.

5. How does an S$^{2-}$ ion differ from an electrically neutral sulfur atom?
   A  mass number
   B  atomic number
   C  nuclear charge
   D  number of electrons

6. A gas under a pressure of 74 mmHg and at a temperature of 75°C occupies a 500.0-L container. How many moles of gas are in the container?
   A  1.7 moles
   B  7.9 moles
   C  13 moles
   D  59 moles
7. A chemistry student is given 5 samples of a metal. The student measures and records the mass and the volume of each sample and then graphs the data, as shown below.

![Mass vs. Volume of a Metal graph]

What is the identity of the metal?

A aluminum  
B iron  
C nickel  
D lead

8. Which orbital notation represents an s-block element in the third period?

A \[ 1s \quad 2s \]

B \[ 1s \quad 2s \quad 2p \quad 3s \]

C \[ 1s \quad 2s \quad 2p \quad 3s \quad 3p \]

D \[ 1s \quad 2s \quad 2p \quad 3s \quad 3p \quad 4s \quad 3d \]
9. What is the volume of 2.00 moles of nitrogen gas (N₂) at STP?

A 11.2 L
B 28.0 L
C 44.8 L
D 56.0 L

10. According to this balanced chemical equation, what volume of C₂H₂ is required to form 40.0 L of CO₂?

\[ 2C₂H₂(g) + 5O₂(g) \rightarrow 2H₂O(g) + 4CO₂(g) \]

A 20.0 L
B 44.8 L
C 80.0 L
D 100 L
11. In an experiment, 2.62 g of iron react completely with 1.50 g of sulfur. What is the empirical formula for the compound produced?

A  FeS  
B  FeS_2  
C  Fe_2S  
D  Fe_2S_3  

12. What do the ions K\(^+\), Ca\(^{2+}\), and Cl\(^-\) have in common?

A  They have the same number of protons.  
B  They will form covalent bonds with oxygen.  
C  They have the same electron configuration as argon.  
D  They are larger than their corresponding atoms.
13. This graph represents a heating curve of a substance.

Which region on the graph represents the solid phase?

A  I
B  II
C  III
D  IV
14. When $^{42}_{19}$K undergoes radioactive decay, the result is two products, one of which is calcium-42. What is the other product?

- **A** $^4_2$He
- **B** $^2_4$He
- **C** $^1_1$e
- **D** $^0_{-1}$e

15. This graph is a potential energy diagram for a chemical reaction.

Which energy measure will remain unchanged with the addition of a catalyst?

- **A** II
- **B** IV
- **C** V
- **D** VI
16. What type of chemical reaction is represented by this balanced equation?

\[ S_8 (s) + 8O_2 (g) \rightarrow 8SO_2 (g) \]

A synthesis  
B decomposition  
C single replacement  
D double replacement

17. Which chemical equation is balanced?

A \[ 2LiOH + CO_2 \rightarrow Li_2CO_3 + H_2O \]  
B \[ 2LiOH + CO_2 \rightarrow 2Li_2CO_3 + H_2O \]  
C \[ LiOH + 3CO_2 \rightarrow 2Li_2CO_3 + H_2O \]  
D \[ 4LiOH + CO_2 \rightarrow Li_2CO_3 + 2H_2O \]

18. Neutralization occurs when 15.0 mL of KOH react with 25.0 mL of HNO₃. If the molarity of HNO₃ is 0.750 \( M \), what is the molarity of the KOH?

A 1.67 \( M \)  
B 1.25 \( M \)  
C 0.600 \( M \)  
D 0.450 \( M \)

19. Which substance can act as either an acid or a base according to the Brønsted-Lowry definition?

A \( H_3O^+ \)  
B \( NH_4^+ \)  
C HOH  
D HCl

20. What is the oxidation number of sulfur in \( \text{BaSO}_4 \)?

A −2  
B 0  
C +1  
D +6
21. This diagram represents a phase diagram for a substance.

At which point do solid, liquid, and gas phases exist in equilibrium?

A 1
B 2
C 3
D 4
22. Using the solubility graph provided, a student performs an experiment to find the solubility of a substance. The student finds the amount of substance needed to make a saturated solution in 100 g of water at different temperatures. The student’s data are shown in the table below the graph.

**Solubility Graph**

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<tr>
<td>0</td>
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<tr>
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</tr>
<tr>
<td>Sodium Nitrate</td>
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<tr>
<td>Potassium Iodide</td>
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<tr>
<td>Potassium Nitrate</td>
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<tr>
<td>Potassium Chlorate</td>
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**Student Data**

<table>
<thead>
<tr>
<th>Trial</th>
<th>Temperature of Water (°C)</th>
<th>Salt in 100 g of Water (g)</th>
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<td>40</td>
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<tr>
<td>2</td>
<td>68</td>
<td>126</td>
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</tbody>
</table>

What is the identity of the substance?

A. Sodium Nitrate
B. Potassium Nitrate
C. Sodium Chloride
D. Potassium Chlorate
23. What is the correct chemical formula for sodium sulfate?

A  NaSO₄
B  Na₂SO₄
C  Na( SO₄)₂
D  Na₄(SO₄)₂

24. Which compound contains both covalent and ionic bonds?

A  CaCO₃
B  CO₂
C  H₂O
D  NaCl

25. In a flexible container, 15.9 L of gas is under 589 kPa of pressure at a temperature of 56.5°C. If the pressure and temperature change to STP, what is the new volume?

A  10.2 L
B  76.6 L
C  92.4 L
D  112 L

26. What are the differences between these isotopes of hydrogen shown below?

$^{1}H$, $^{2}H$, and $^{3}H$

A  the number of electrons and the atomic number
B  the number of protons and the atomic number
C  the number of neutrons and the mass number
D  the number of electrons and protons

27. What is the correct name for the acid whose chemical formula is H₂SO₄?

A  hydrosulfuric acid
B  hydrosulfurous acid
C  sulfurous acid
D  sulfuric acid

28. Which element is located in Group 2 (IIA) and Period 6 of the periodic table?

A  barium (Ba)
B  molybdenum (Mo)
C  radium (Ra)
D  tungsten (W)
29. How many moles are in 325 g of $(NH_4)_2Cr_2O_7$?
   A 0.732 mole
   B 0.776 mole
   C 1.29 moles
   D 1.37 moles

30. Which compound contains the greatest percent of oxygen by mass?
   A CO$_2$
   B NO$_2$
   C SO$_2$
   D SiO$_2$

31. This balanced equation represents a chemical reaction:
   $$2KClO_3(s) \xrightarrow{\Delta} 2KCl(s) + 3O_2(g)$$

   How many moles of KCl are produced when 4.25 moles of KClO$_3$ decompose?
   A 1.06 moles
   B 2.13 moles
   C 4.25 moles
   D 8.50 moles

32. Considering this balanced chemical equation, how many grams of HgO will be produced when 44 g of Hg react with excess O$_2$?
   $$2Hg(l) + O_2(g) \rightarrow 2HgO(s)$$
   A 28 g
   B 44 g
   C 48 g
   D 96 g

33. Which electron transmission in the hydrogen atom will result in the emission of red light?
   A $n = 2$ to $n = 3$
   B $n = 2$ to $n = 4$
   C $n = 3$ to $n = 2$
   D $n = 4$ to $n = 2$

34. What can be said of a closed system when an exothermic reaction proceeds in an aqueous solution?
   A There is a net energy loss.
   B There is a net energy gain.
   C Heat is transferred from the water to the reactants.
   D Heat is transferred from the reactants to the water.
35. In which group are the particles arranged in order of decreasing mass?
   A alpha, beta, neutron
   B alpha, neutron, beta
   C neutron, beta, alpha
   D neutron, alpha, beta

36. Consider this incomplete chemical equation:

\[
\text{Ba} + \text{CuCl}_2 \rightarrow
\]

What are the products of this equation?
   A \( \text{BaCl}_2 \) and \( \text{CuCl}_2 \)
   B \( \text{BaCuCl}_2 \) and \( \text{Ba} \)
   C \( \text{BaCl}_2 \) and \( \text{Cu} \)
   D \( \text{BaCu} \) and \( \text{Cl}_2 \)

37. What is the best reason for using iron filings instead of an iron nail in a chemical reaction?
   A to decrease the amount of catalyst during the reaction
   B to increase the molecular structure during the reaction
   C to decrease the rate of reaction
   D to increase the surface area of the reaction

38. Which is a characteristic of a strong acid?
   A It has a pH greater than 7.
   B It completely ionizes in solution.
   C It contains many hydroxide ions.
   D It reacts only with a strong base.
39. Consider this balanced chemical equation:

\[ \text{
Zn (s) + 2HCl (aq) → ZnCl}_2 (aq) + \text{H}_2 (g)
\]

Which is the oxidation half-reaction?

A \[ \text{Zn} \rightarrow \text{Zn}^{2+} + 2e^- \]

B \[ \text{Zn} + 2e^- \rightarrow \text{Zn}^{2+} \]

C \[ 2\text{H}^+ \rightarrow \text{H}_2 + 2e^- \]

D \[ 2\text{H}^+ + 2e^- \rightarrow \text{H}_2 \]

40. What is the net ionic equation for the reaction between Pb(NO\(_3\))\(_2\) and HCl?

A \[ \text{Pb}^{2+} (aq) + 2\text{Cl}^- (aq) \rightarrow \text{PbCl}_2 (s) \]

B \[ 2\text{NO}_3^- (aq) + 2\text{H}^+ (aq) \rightarrow 2\text{HNO}_3 (aq) \]

C \[ \text{Pb(NO}_3)_2 (aq) + 2\text{HCl (aq) } \rightarrow \text{PbCl}_2 (s) + 2\text{HNO}_3 (aq) \]

D \[ \text{Pb}^{3+} (aq) + 2\text{NO}_3^- (aq) + 2\text{H}^+ (aq) + 2\text{Cl}^- (aq) \rightarrow \text{PbCl}_2 (s) + 2\text{H}^+ (aq) + 2\text{NO}_3^- (aq) \]
41. When combined, two gases have a pressure of 4.0 atm. If one gas has a pressure of 1.5 atm, what is the pressure of the second gas?

A 1.5 atm  
B 2.0 atm  
C 2.5 atm  
D 5.5 atm

42. What compound has the chemical formula MgI₂?

A di-iodide magnesium  
B iodide(II) magnesium  
C magnesium iodide  
D magnesium(I) iodine(II)

43. Which elements have the same number of neutrons?

A \(^{10}\)B and \(^{12}\)C  
B \(^{55}\)Mn and \(^{56}\)Fe  
C \(^{108}\)Ag and \(^{112}\)Cd  
D \(^{197}\)Au and \(^{201}\)Hg
44. This chart represents the melting point of several substances.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting Point (°C)</th>
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<tr>
<td>Cl₂</td>
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<td>Na</td>
<td>97.72</td>
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<tr>
<td>NaCl</td>
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</tbody>
</table>

What **best** explains the high melting point of the salt?

A. the strong electrostatic attraction between Na\(^0\) and Cl\(^0\)
B. the weak electrostatic attraction between Na\(^0\) and Cl\(^0\)
C. the weak electrostatic attraction between Na\(^+\) and Cl\(^-\)
D. the strong electrostatic attraction between Na\(^+\) and Cl\(^-\)

45. Based on the VSEPR theory, what is the molecular geometry of CO\(_2\)?

A. linear
B. tetrahedral
C. trigonal planar
D. trigonal pyramidal
46. This graph represents a phase diagram for a substance.

![Phase Diagram]

What is the state of the substance at point I?

A gas
B liquid
C liquid and gas
D solid and liquid

47. Which one of these compounds is soluble in water?

A aluminum sulfide
B calcium carbonate
C iron(III) hydroxide
D potassium sulfate

48. In which block does an element with the electron configuration [Xe] 6s²4f¹⁴5d¹⁰6p¹ belong?

A s block
B p block
C d block
D f block
49. Which statement is true for the reaction represented by this equation?

\[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]

A 1 gram of CH\(_4\) is required to react with 2 grams of O\(_2\).

B 1 gram of CH\(_4\) is required to react with 4 grams of O\(_2\).

C 1 mole of CH\(_4\) is required to react with 2 moles of O\(_2\).

D 1 mole of CH\(_4\) is required to react with 4 moles of O\(_2\).

50. What is the percent by mass of N in Ca(CN)\(_2\)?

A 15.21%

B 21.19%

C 30.42%

D 42.39%

51. Which orbital notation shows the lowest energy arrangement of valence electrons for 1s\(^2\)2s\(^2\)2p\(^3\)?

A \[ \begin{array}{cc}
2s & \uparrow \\
2p & \uparrow \uparrow \uparrow \\
\end{array} \]

B \[ \begin{array}{cc}
2s & \downarrow \\
2p & \uparrow \uparrow \uparrow \\
\end{array} \]

C \[ \begin{array}{cc}
2s & \downarrow \\
2p & \uparrow \uparrow \uparrow \\
\end{array} \]

D \[ \begin{array}{cc}
2s & \downarrow \\
2p & \uparrow \uparrow \uparrow \\
\end{array} \]

52. What is the molarity of 28.9 g of CaCl\(_2\) dissolved in water to make 0.78 L of solution?

A 0.33 \( M \)

B 0.69 \( M \)

C 1.5 \( M \)

D 3.0 \( M \)
53. The half-life of phosphorus-32 is 14.3 days. How much of a sample of phosphorus-32 will remain after 57.2 days?

A  \( \frac{1}{32} \)  
B  \( \frac{1}{16} \)  
C  \( \frac{1}{8} \)  
D  \( \frac{1}{4} \)  

54. To increase the temperature of 100.0 g of \( H_2O \) (s) from -50.0°C to -10.0°C, how much energy is required?

A  \( 1.67 \times 10^4 \) J  
B  \( 8.20 \times 10^3 \) J  
C  \( 8.08 \times 10^3 \) J  
D  \( 1.95 \times 10^3 \) J  

55. What is the \( [H^+] \) of an HCl solution if the pH is measured to be 6?

A  \( 1 \times 10^{-7} \) M  
B  \( 1 \times 10^{-6} \) M  
C  \( 6 \times 10^{-6} \) M  
D  \( 8 \times 10^{-1} \) M
56. This balanced equation represents a chemical reaction.

\[ 2C_4H_{10} (g) + 13O_2 (g) \rightarrow 8CO_2 (g) + 10H_2O (g) \]

What type of chemical reaction is represented by the equation?

A  combustion  
B  decomposition  
C  double replacement  
D  single replacement

57. This balanced equation represents a chemical reaction using palladium, Pd, as a catalyst.

\[ CO_2 (g) + H_2O (l) \xrightarrow{(Pd)} H_2CO_3 (l) \]

Without palladium the reaction is slow and produces low concentrations of product. How does the palladium increase the speed of the reaction?

A  The palladium reacts with the water.  
B  The palladium lowers the activation energy.  
C  The palladium purifies the carbon dioxide.  
D  The palladium increases the reaction temperature.

58. Which pair of substances will likely undergo a single replacement reaction?

A  Na and BaCl₂  
B  Zn and BaCl₂  
C  Ca and BaCl₂  
D  K and BaCl₂
59. What is the net ionic equation for the reaction between aqueous solutions of LiBr and AgNO₃?

A. \( \text{Ag}^+ (aq) + \text{Br}^- (aq) \rightarrow \text{AgBr} (s) \)

B. \( \text{Li}^+ (aq) + \text{NO}_3^- (aq) \rightarrow \text{LiNO}_3 (s) \)

C. \( \text{Li}^+ (aq) + \text{Br}^- (aq) \rightarrow \text{LiBr} (s) \)

D. \( \text{Ag}^+ (aq) + \text{NO}_3^- (aq) \rightarrow \text{AgNO}_3 (s) \)

60. A scientist hypothesizes that a colorless gas produced during a chemical reaction is carbon dioxide. Which observation would confirm this hypothesis?

A. The gas will react violently with water.

B. A glowing splint placed in the gas will burn brighter.

C. Burning the gas in the presence of oxygen will produce water.

D. Bubbling the gas through lime water will make the lime water cloudy.
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<th>Item Number</th>
<th>Correct Answer</th>
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