

Academic Challenge
Chemistry Test (Sectional) – 2022

1. The following table shows some liquids and their respective densities.

name	pentane	carbon tetrachloride	diiodomethane	mercury
density	0.626 g/mL	1.58 g/mL	3.33 g/mL	13.7 g/mL

Which liquid occupies the largest volume if equal masses of each liquid are compared?

- A. pentane
 - B. carbon tetrachloride
 - C. diiodomethane
 - D. mercury
 - E. all occupy the same volume
2. Which formula is incorrect?
- A. NaCO_3
 - B. BaSO_4
 - C. $\text{Ca}(\text{OH})_2$
 - D. NH_4NO_3
 - E. KI
3. The number of unshared electron pairs around the central sulfur atom in the H_2S molecule is:
- A. 0
 - B. 1
 - C. 2
 - D. 3
 - E. 4
4. The temperature of a 2.0×10^2 g metal bar increases from 0.0°C to 100.0°C when it absorbs 5.0 kJ of heat. What is the specific heat of the metal?
- A. $2.5 \times 10^{-4} \text{ J}/(\text{g} \cdot ^\circ\text{C})$
 - B. $0.10 \text{ J}/(\text{g} \cdot ^\circ\text{C})$
 - C. $10 \text{ J}/(\text{g} \cdot ^\circ\text{C})$
 - D. $0.25 \text{ J}/(\text{g} \cdot ^\circ\text{C})$
 - E. $70 \text{ J}/(\text{g} \cdot ^\circ\text{C})$

5. Which has the smallest dipole-dipole forces?

- A. CH_3Cl
- B. O_2
- C. NO
- D. HBr
- E. CO

6. How many of the following substances are acidic?

I) $\text{pH} = 5.9$	II) $\text{pOH} = 12$	III) $[\text{H}^+] = 1.2 \times 10^{-8} \text{ M}$
IV) $\text{pH} = 9.4$	V) $[\text{H}^+] = 8.1 \times 10^{-3} \text{ M}$	VI) $[\text{OH}^-] = 7.5 \times 10^{-5} \text{ M}$

- A. 1
- B. 2
- C. 3
- D. 4
- E. 5

7. What is the volume of one mole of CO_2 at STP?

- A. 44 L
- B. 24.2 mL
- C. 24.2 L
- D. 22.4 mL
- E. 22.4 L

8. Which form of electromagnetic radiation has the longest wavelength and the least amount of energy?

- A. x-rays
- B. radio waves
- C. visible light
- D. gamma radiation
- E. microwaves

9. What is the most likely formula of a binary compound of calcium and phosphorus?

- A. CaP
- B. Ca_3P_2
- C. CaK
- D. CaPO_4
- E. $\text{Ca}(\text{PO}_3)_3$

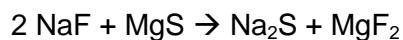
10. Which of the following substances possesses polar bonds, but is a nonpolar molecule?

- A. CO_2
- B. Cl_2
- C. HF
- D. H_2O
- E. NaCl

11. The following table shows the standard enthalpies of formation, ΔH°_f , of some compounds at 298 K.

Compound	NaF	MgS	Na_2S	MgF_2
ΔH°_f (kJ/mol)	-569	-347	-373	-1102

Calculate the change in enthalpy of reaction, $\Delta H^\circ_{\text{rxn}}$, in kJ for the following reaction at 298 K.



- A. -2391 kJ
- B. +2391 kJ
- C. +10 kJ
- D. +559 kJ
- E. -559 kJ

12. Choose the pair of substances that are most likely to form a homogeneous solution.

- A. KI and Hg
- B. C_3H_8 and $\text{C}_2\text{H}_5\text{OH}$
- C. F_2 and PF_3
- D. NH_3 and CH_3OH
- E. F_2 and KI

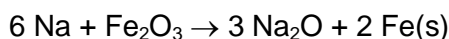
13. What is the $[\text{OH}^-]$ concentration and pH of a solution that is 1×10^{-4} M in hydrogen ion?

- A. $\text{pH} = 4.0$, $[\text{OH}^-] = 1 \times 10^{-4}$ M
- B. $\text{pH} = 10.0$, $[\text{OH}^-] = 1 \times 10^{-4}$ M
- C. $\text{pH} = 10.0$, $[\text{OH}^-] = 1 \times 10^{-10}$ M
- D. $\text{pH} = 6.0$, $[\text{OH}^-] = 1 \times 10^{-10}$ M
- E. $\text{pH} = 4.0$, $[\text{OH}^-] = 1 \times 10^{-10}$ M

14. The correct name for Al_2S_3 is:

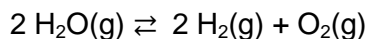
- A. aluminum sulfite
- B. aluminum bisulfite
- C. dialuminum trisulfur
- D. aluminum sulfide
- E. sulfur aluminate

15. Suppose 200.0 g of sodium and 250.0 g of iron(III) oxide are allowed to react. How much of the iron(III) oxide would remain after the following reaction is complete?



- A. 125 g
- B. 250 g
- C. 231 g
- D. 18.5 g
- E. 450 g

16. Consider the gas-phase equilibrium system represented by the equation:



If the forward reaction (left to right) is exothermic, which of the following changes will increase the equilibrium amount of H_2 ?

- A. decreasing the temperature at constant pressure
- B. adding more oxygen
- C. increasing the volume of the container (the total pressure increases)
- D. removing water
- E. adding a catalyst

17. What is the osmotic pressure of a 150 mL solution that contains 3.85 g of sucrose ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) at 18.5°C ?

- A. 0.114 atm
- B. 1.36 atm
- C. 18.0 atm
- D. 1.79 atm
- E. 11.4 atm

18. In general, atomic radius _____ as you go up, and _____ as you go from right to left across the periodic table.
- A. decreases, decreases
 - B. decreases, increases
 - C. increases, decreases
 - D. increases, increases
 - E. cannot be determined
19. Ionization energy generally increases from left to right on the periodic table; however, the ionization energy of beryllium is higher than that of boron. What best explains this observation?
- A. Beryllium has less valence electrons.
 - B. The first electron removed from beryllium is a core electron while the first removed from boron is valence.
 - C. Boron is a nonmetal while beryllium is a metal.
 - D. Beryllium has less valence electrons than boron.
 - E. Losing an electron from beryllium disrupts a stable electron configuration, while losing one from boron creates a stable electron configuration.
20. What is the molarity of a NaNO_3 solution made by diluting 250.0 mL of a 1.60 *M* solution with 150.0 mL of water?
- A. 1.20 *M*
 - B. 1.00 *M*
 - C. 0.200 *M*
 - D. 0.160 *M*
 - E. 2.67 *M*
21. A light source containing 2.551×10^{15} photons has an energy of 50 mJ. What is the frequency of this light?
- A. $5.96 \times 10^{14} \text{ s}^{-1}$
 - B. $-3.55 \times 10^{16} \text{ s}^{-1}$
 - C. 10.1 s^{-1}
 - D. $3.38 \times 10^{-17} \text{ s}^{-1}$
 - E. $2.96 \times 10^{16} \text{ s}^{-1}$
22. Provide the value(s) for m_l for an “f” orbital.
- A. -2, -1, 0, 1, 2
 - B. -1, 0, 1
 - C. -3, -2, -1, 0, 1, 2, 3
 - D. 4
 - E. 0, 1, 2, 3, 4

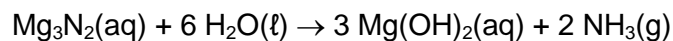
23. Calcium reacts with a certain element (X) to form a compound with the general formula CaX. What would the valence electron configuration of element X?

- A. s^2p^5
- B. s^2p^6
- C. s^2p^4
- D. s^2p^3
- E. none of these

24. How many grams of magnesium nitrate need to be dissolved in 250.0 g of water to produce a 0.0750 molar solution?

- A. 2.78 g
- B. 1.39 g
- C. 2.19 g
- D. 0.800 g
- E. 1.61 g

25. A student used 0.400 L of water in the reaction below. If 6.5 mol NH_3 gas were produced how much water remained unreacted?



- A. 351.4 mL
- B. 39.0 mL
- C. 361.0 mL
- D. 48.6 mL
- E. 19.5 mL

26. Which electronic transition results in the emission of light with the longest wavelength?

- A. $1 \rightarrow 3$
- B. $4 \rightarrow 1$
- C. $4 \rightarrow 3$
- D. $4 \rightarrow 5$
- E. $3 \rightarrow 2$

27. Consider this reaction. $\text{AB}_3(\text{g}) \rightleftharpoons \text{A}(\text{g}) + 3\text{B}(\text{g})$

What is the correct expression for the equilibrium concentration of **B** if the initial concentration of **B** is 0.1 M?

- A. $0.1 - 3x$
- B. $3x$
- C. $0.1 + X^3$
- D. $(3x)^3$
- E. $0.1+3x$

28. How many significant figures are being expressed in the quantity 0.0040320 moles?

- A. 3
- B. 4
- C. 5
- D. 6
- E. 7

29. Which of the following conversion factors is exact?

- A. $\frac{6.022 \text{ atoms}}{1 \text{ mole}}$
- B. $\frac{1 \text{ kilometers}}{0.621371 \text{ miles}}$
- C. $\frac{1 \text{ liter}}{1.05669 \text{ quarts}}$
- D. $\frac{1 \text{ ounce}}{28.35 \text{ grams}}$
- E. $\frac{2.54 \text{ centimeters}}{1 \text{ inch}}$

30. What is the most likely charge on a polyatomic ion with the form AB_3 where A has an oxidation state of -2 and B has an oxidation state of +1?

- A. +3
- B. +2
- C. -2
- D. +1
- E. -1

31. What ion is represented by the following composition: 6 protons, and 7 electrons?

- A. B^{2-}
- B. B^+
- C. B^-
- D. C^+
- E. C^-

32. What is the percent composition of phosphorus in ammonium phosphate?

- A. 27.4 %
- B. 22.1 %
- C. 63.7 %
- D. 20.8 %
- E. 4.01 %

33. Which of the following assumptions is a valid conclusion from the Henderson-Hasselbalch equation?
- A. The pH is equal to the pK_a value if the equilibrium concentrations of the acid and conjugate base are the same.
 - B. The pH is equal to the pK_a value if the equilibrium concentration of the acid is ten times greater the concentration of conjugate base.
 - C. The pH is equal to the pK_a value if the equilibrium concentration of the base is ten times greater the concentration of acid.
 - D. The pH will always be greater than the pK_a when the equilibrium concentration of acid exceeds the concentration of conjugate base.
 - E. The pH will always be greater than the pK_a when the equilibrium concentration of acid equals the concentration of conjugate base.
34. A compound consisting of mercury and chlorine was analyzed and found to contain 73.924 % mercury and 26.082 % chlorine. What is the empirical formula for this compound?
- A. $HgCl$
 - B. $HgCl_2$
 - C. Hg_2Cl
 - D. Hg_2Cl_2
 - E. Hg_2Cl_4
35. All of the following statements, except for one, are valid conclusions of kinetic collision theory. Which one of these statements is NOT true?
- A. When the number of total collisions between reactants decreases, the rate of the reaction will decrease.
 - B. The orientation of reactants during a collision is an important indicator of whether the reaction will occur or not.
 - C. The greater the temperature in a chemical reaction, the more collisions will occur.
 - D. Reactants separated by a barrier will never be able to react no matter how fast the reactants are moving.
 - E. Any collision between two reactants will result in the formation of a new molecule, called the product.
36. Which of these scientists is responsible for the claim that electrons orbiting an atom should have an orbital circumference that is an integer multiple of the electron's wavelength?
- A. Louis de Broglie
 - B. Max Planck
 - C. Linus Pauling
 - D. Wolfgang Pauli
 - E. Erwin Schrödinger

37. How should the rate constant in kinetics experiments be interpreted?
- A. It is an indication of how hot the reaction is.
 - B. It is an indication of how much the rate will increase with a corresponding increase in reactant concentrations.
 - C. It is an indication of how much energy is needed to overcome the activation energy barrier in a chemical reaction.
 - D. It is an indication of what the combined order is for all of the reactants in a chemical reaction.
 - E. It is an indication of how much heat has to be added to make a chemical reaction begin.
38. How many of the elements in period 2 of the periodic table are diamagnetic in their neutral, monatomic forms?
- A. 0
 - B. 1
 - C. 2
 - D. 4
 - E. 6
39. The corrosion of iron may proceed as shown in the following reaction. Identify the oxidizing agent.
- $$2\text{Fe(s)} + \text{O}_2\text{(g)} + 4\text{H}^+\text{(aq)} \rightarrow 2\text{Fe}^{2+}\text{(aq)} + 2\text{H}_2\text{O(l)}$$
- A. Fe(s)
 - B. O₂(g)
 - C. H⁺(aq)
 - D. Fe²⁺(aq)
 - E. H₂O(l)
40. If a redox reaction at 298 K has an $E^{\circ}_{\text{cell}} = -0.15 \text{ V}$, a reaction quotient of $Q = 0.19$ and 2 moles of electrons are transferred per mole of reaction, what is the non-standard cell potential?
- A. -0.13 V
 - B. -0.17 V
 - C. 0.13 V
 - D. 0.17 V
 - E. -0.10 V