# CHEMISTRY PRACTICE TEST 1

## Multiple Choice Questions Section I

90 minutes

You may not use a calculator for this section.

**Directions:** Each set of lettered responses refers to the numbered statements or questions immediately below it. Choose the one-lettered response that best fits each statement or question. You may use a response once, more than once, or not at all.

### Questions 1–5 refer to the following aqueous solutions.

A) 0.1 M $Na_3PO_4$
B) 0.1 M $CaCl_2$
C) 0.1 M $CH_3CH_2OH$
D) 0.1 M $HNO_3$
E) 0.2 M $NH_4Cl$

1. Which solution has a pH of approximately 7?
2. Which solution will cause a solution of sodium hydrogen carbonate to produce a gas?
3. Which solution is basic?
4. Which solution will react with an equal molar amount of hydrochloric acid to form a weakly basic solution?
5. Which solution will form a water-soluble gas upon reaction with sodium hydroxide?

### Questions 6–10 refer to the following elements.

A) Cl
B) Ba
C) F
D) Ne
E) B

6. Which element has the largest first ionization energy?
7. Which element has the largest difference between the second and third ionization energies?
8. Which element has the largest electron affinity?
9. Which element has the smallest atomic radius?
10. Which element has the most oxidation states?

**Questions 11–13 refer to the following data table.**

The table lists the solubilities, in grams of solute per 100 g of $H_2O$, of various salts at two different temperatures.

| | Salt | 20°C | 60°C |
|---|---|---|---|
| I | $Ce_2(SO_4)_3 \cdot 9H_2O$ | 9.16 | 3.73 |
| II | $KNO_3$ | 31.6 | 110.0 |
| III | NaCl | 36.0 | 37.3 |
| IV | $K_2Cr_2O_7$ | 13.1 | 50.5 |

11. For which of these salts will the solution process have a $\Delta H$ closest to zero?

    A) I
    B) II
    C) III
    D) IV
    E) I and II

12. Which of these salts dissolve exothermically?

    A) I
    B) II
    C) III
    D) IV
    E) II, III, and IV

13. For which of these salts is entropy but not enthalpy the driving force for dissolution?

    A) I
    B) II
    C) III
    D) IV
    E) II, III, and IV

**Directions:** For each of the following questions or incomplete statements, select the letter of the best answer or completion directly below it.

14. The energy absorbed when dry ice sublimes is required to overcome which type of interaction?

    A) covalent bonds
    B) ion–dipole forces
    C) dipole–dipole forces
    D) dispersion forces
    E) hydrogen bonds

15. A container is half filled with a liquid and sealed at room temperature and atmospheric pressure. What happens inside the container?

    A) Evaporation stops.
    B) Evaporation continues for a time and then stops.

C) The pressure in the container remains constant.
D) The pressure inside the container increases for a time and then remains constant.
E) The liquid evaporates until it is all in the vapor phase.

16. Acetone, $(CH_3)_2C = O$, is a volatile, flammable liquid. The central carbon is $sp^2$ hybridized. The strongest intermolecular forces present in a sample of acetone are

A) dipole–dipole forces.
B) London dispersions.
C) hydrogen bonds.
D) covalent bonds.
E) ion–dipole forces.

17. Heating $Br_2O_7$ causes it to decompose into its gaseous elements. What is the ratio of bromine to oxygen molecules in the product?

A) 1 to 7
B) 2 to 7
C) 7 to 2
D) 7 to 1
E) 1 to 14

18. Complete combustion of a compound containing only carbon, hydrogen, and oxygen yields data that allow for elemental analysis. The analysis of the combustion products relies upon which of these assumptions?

I. The quantity of carbon dioxide formed relates directly to the amount of carbon present in the sample.
II. The quantity of water formed relates directly to the amount of hydrogen present in the sample.
III. The quantity of water formed is limited by the amount of oxygen present in the sample.
IV. The quantity of carbon dioxide formed is limited by the amount of air present.

A) I only
B) II only
C) I, II, and III only
D) I and II only
E) I, II, III, and IV

19. A sample of hydrated copper(II) sulfate, $CuSO_4 \cdot xH_2O$, weighs 24.95 g. When the water is driven off, the anhydrous form weighs 15.95 g. What is the value of $x$ in the formula of the hydrated salt?

A) 1
B) 2
C) 3
D) 4
E) 5

20. A compound whose empirical formula is $C_2H_4O$ has a molar mass that lies between 100 and 150 g/mol. What is the molecular formula of the compound?

A) $C_2H_4O$
B) $C_4H_8O_2$
C) $C_6H_{12}O_3$
D) $C_6H_{12}O_2$
E) $C_6H_8O_3$

21. Atom Y has three valence electrons and atom Z has six valence electrons. What is the simplest formula expected for the binary ionic compound composed of Y and Z?

A) $Y_2Z$
B) $YZ_2$
C) $Y_2Z_3$
D) $Y_3Z_2$
E) YZ

22. For the following reaction, $\Delta H = -400$ kJ.
$2K(s) + 2H_2O(l) \rightarrow 2KOH\ (aq) + H_2(g)$
Calculate $\Delta H$ for this reaction.
$KOH\ (aq) + 1/2H_2(g) \rightarrow K(s) + H_2O(l)$

A) −400 kJ
B) +400 kJ
C) −200 kJ
D) +200 kJ
E) −100 kJ

23. The physical behavior of an ideal gas is dependent on all the following except

A) temperature.
B) volume.
C) pressure.
D) number of moles.
E) chemical composition.

24. The kinetic-molecular theory predicts that two different gases at the same temperature will have the same

A) average speed.
B) average kinetic energy.
C) pressure.
D) rate of effusion.
E) volume.

25. Gases tend to exhibit nonideal behavior under conditions of

A) low temperature and low pressure.
B) low temperature and high pressure.
C) high temperature and high pressure.
D) high temperature and low pressure.
E) any temperatures above the critical temperature.

26. A total of 1 L of oxygen gas, $O_2$, and 3 L of sulfur dioxide gas, $SO_2$, react to form gaseous sulfur trioxide, $SO_3$, at a given temperature and pressure. How many liters of $SO_3(g)$ can be produced at that same temperature and pressure?

A) 1
B) 2
C) 3
D) 4
E) 6

27. Which gas deviates the most from ideal behavior?

A) $H_2$
B) Ne
C) $H_2O$
D) $CH_4$
E) $N_2$

28. Based on effective nuclear charge, predict which element will have the smallest atomic radius.

A) H
B) He
C) Li
D) Be
E) B

29. Which element has the smallest first ionization energy?

A) Ca
B) Ga
C) Ge
D) As
E) Br

30. For which pair of atoms is the electronegativity difference the greatest?

A) Al, Si
B) Li, Br
C) Rb, Cl
D) Se, S
E) N, O

31. Which one of the following does not have a valid octet Lewis structure?

A) $SeCl_4$
B) $CCl_4$
C) $SO_4^{2-}$
D) $PF_3$
E) $NO_3^-$

32. Which of the following diatomic molecules has the strongest bonds?

A) $N_2$
B) $O_2$
C) $F_2$
D) $Cl_2$
E) $Br_2$

33. The hybrid orbitals of carbon in $CO_3^{2-}$ are

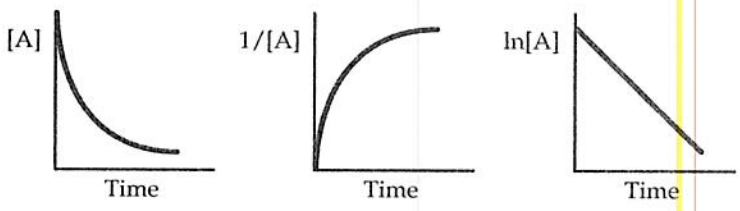
A) *sp*.
B) $sp^2$.
C) $sp^3$.
D) $dsp^3$.
E) $d^2sp^3$.

34. Which molecules are polar?

I. $H_2O$
II. $CO_2$
III. $NO_2$
IV. $SO_2$

A) I only
B) I and III only
C) I, II, and III only
D) I, II, III, and IV
E) I, III, and IV only

35. The experimental data from the reaction A → products give these three graphs. What is the most likely order for this reaction?




A) zero
B) first
C) second
D) third
E) not enough information to conclude

36. The rate of a chemical reaction between substances A and B is found to follow the rate equation, rate=$k$ [X][Y]$^2$. If the concentration of Y is halved, what condition would result in keeping the reaction rate constant, assuming no temperature change?

A) If [X] remains constant.
B) If [X] is doubled.
C) If [X] is halved.
D) If [X] is tripled.
E) If [X] is quadrupled.

37. What statement is true about the energy diagram for a reversible endothermic reaction?

A) The energy of activation is greater for the reverse reaction than for the forward reaction.
B) The energy of activation is greater for the forward reaction than for the reverse reaction.
C) The energy of activation is the same for the reaction in both directions.
D) The enthalpy of reactants is greater than the enthalpy of products.
E) The forward reaction is faster than the reverse reaction.

38. Strontium-90 undergoes radioactive decay with a half-life of about 30 years. Approximately how many years will have elapsed before 97% of the $^{90}Sr$ in a sample will have decayed?

A) 30
B) 60
C) 120
D) 150
E) 180

39 When the following reaction in aqueous solution is balanced using whole number coefficients, what is the coefficient of $H^+$?

$MnO_4^- + NO_2 \rightarrow MnO_2 + NO_3^-$

A) 2
B) 4
C) 5
D) 6
E) 8

40. Which of these is most easily oxidized?

A) fluorine
B) fluoride ion
C) aluminum
D) aluminum ion
E) silver ion

| Oxidized/Reduced Substances | Half-Reaction | $E°$ (V) |
|---|---|---|
| $F_2/F^-$ | $F_2(g) + 2e^- \rightarrow 2F^-(aq)$ | +2.87 |
| $Cl_2/Cl^-$ | $Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$ | +1.359 |
| $Ag^+/Ag$ | $Ag^+(aq) + 1e^- \rightarrow Ag(s)$ | +0.799 |
| $Zn^{2+}/Zn$ | $Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ | −0.762 |
| $Al^{3+}/Al$ | $Al^{3+}(aq) + 3e^- \rightarrow Al(s)$ | −1.66 |

41. Calculate the voltage for a cell consisting of the following half-cells suitably connected.

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s) \quad E° = 0.337\ V$

$Al^{3+}(aq) + 3e^- \rightarrow Al(s) \quad E° = -1.66\ V$

A) 1.32 V
B) 2.00 V
C) 2.30 V
D) −2.30 V
E) 4.33 V

42. Each of the following is amphoteric except

A) $HSO_3^-$.
B) $HPO_4^{2-}$.
C) $NH_4^+$.
D) $H_2O$.
E) $HS^-$.

43. Which of the following species is in the greatest concentration in an aqueous 0.100 molar solution of $H_3PO_4$?

A) $H_3O^+$
B) $H_3PO_4$
C) $H_2PO_4^-$
D) $HPO_4^{2-}$
E) $PO_4^{3-}$

44. Which substance in aqueous solution is an electrolyte and is also basic?

A) HCl
B) $CH_3COOH$
C) $CH_3OH$
D) KOH
E) $NH_4NO_3$

45. Which is expected to be the weakest acid?

A) HClO
B) $HClO_2$
C) $HClO_3$
D) $HClO_4$
E) HCl

46. The solubility of which compound is pH dependent?

A) $CaF_2$
B) $KNO_3$
C) NaCl
D) $CH_3OH$
E) $LiClO_4$

47. A total of 20 mL of 0.10 M solutions of each of the following acids are exactly neutralized with 20 mL of 0.10 M NaOH. Which of the resulting solutions has the highest pH?

A) $CH_3COOH$ $(K_a = 1.8 \times 10^{-5})$
B) HCN $(K_a = 4.9 \times 10^{-10})$
C) HBrO $(K_a = 2.5 \times 10^{-9})$
D) HIO $(K_a = 2.3 \times 10^{-11})$
E) $HN_3$ $(K_a = 2.0 \times 10^{-5})$

48. Which species is predicted to act as an acid according to the Brønsted–Lowry theory of acids and bases?

A) NaH
B) $NH_4^+$
C) $Mg_3N_2$
D) $NH_2^-$
E) $O_2^-$

49. If the following system held at constant volume is at equilibrium $PCl_3(g) + Cl_2(g) \leftrightarrows PCl_5(g)$, $\Delta H = -92.6$ kJ, the concentration of $PCl_3$ will decrease if

A) $Cl_2$ is removed from the system.
B) $PCl_5$ is removed from the system.
C) the temperature of the system is increased.
D) an inert gas is added to the system.
E) a catalyst is added.

50. Which is the correct equilibrium-constant expression for the reaction $2\,NO_2(g) \leftrightarrows N_2O_4(g)$?

A) $K_c = [NO_2]/[N_2O_4]$
B) $K_c = [N_2O_4]/[NO_2]$
C) $K_c = [N_2O_4]/[NO_2]^2$
D) $K_c = [N_2O_4]/2\,[NO_2]$
E) $K_c = [NO_2]^2/[N_2O_4]$

51. Determine the value of the equilibrium constant for the following reaction when the equilibrium concentrations are
$[N_2] = 2.0$ M $[H_2] = 2.0$ M $[NH_3] = 2.0$ M
$N_2(g) + 3H_2(g) \leftrightarrows 2\,NH_3(g)$

A) 0.25
B) 0.50
C) 0.75
D) 1.00
E) 2.00

52. Which change will cause the value of the equilibrium constant for the following reaction to decrease?

$X(g) + 2Y(g) \leftrightarrows 2Z(g) \qquad \Delta H = +120\ kJ$

A) adding a catalyst
B) decreasing the concentration of X
C) decreasing the concentration of Z
D) decreasing the temperature
E) decreasing the volume of the container

53 A mixture of 1.00 mol of $H_2(g)$ and 1.00 mol of $I_2(g)$ is placed in a 1.00 L flask at a constant temperature and allowed to come to equilibrium according to the equation

$H_2(g) + I_2(g) \leftrightarrows 2\ HI(g)$

If the equilibrium constant at this temperature is $K_c = 36.0$, what is the molar concentration of $H_2(g)$ in the equilibrium mixture?

A) 0.500 M
B) 1.00 M
C) 0.750 M
D) 0.250 M
E) 0.125 M

54. The neutral atom with the largest electronegativity is

A) Na.
B) Al.
C) P.
D) Cl.
E) Ar.

55. What is the molar solubility of silver chloride ($K_{sp} = 1.8 \times 10^{-10}$) in 0.050 M sodium chloride?

A) $(1.8/0.050) \times 10^{-10}$ M
B) $(1.8/0.050)^{1/2} \times 10^{-5}$ M
C) $(0.050/1.8)^{1/2} \times 10^{-5}$ M
D) $(0.050/1.8) \times 10^{-10}$ M
E) $(1.8/0.050)^2 \times 10^{-5}$ M

56. What is the expected result when 100 mL of a solution that is 0.20 M $Ca(NO_3)_2$ and 0.0020 M $Pb(NO_3)_2$ is mixed with 100 mL of 0.002 M $Na_2SO_4$? The $K_{sp}$ of $CaSO_4$ is $2.4 \times 10^{-5}$ and the $K_{sp}$ of $PbSO_4$ is $6.3 \times 10^{-7}$.

A) Both $CaSO_4$ and $PbSO_4$ will precipitate.
B) Only $CaSO_4$ will precipitate.
C) Only $PbSO_4$ will precipitate.
D) Neither $CaSO_4$ nor $PbSO_4$ will precipitate.
E) Only lead(II) nitrate will precipitate.

57. For the isoelectronic series below, which species requires the least energy to remove an outer electron?

A) $O^{2-}$
B) $F^-$
C) Ne
D) $Na^+$
E) $Mg^{2+}$

58. Which species below does not violate the octet rule?

A) NO
B) $BF_3$
C) $N_2O$
D) $NO_2$
E) $BrF_3$

59. How do the properties of the following reaction vary as the reactions proceed from reactants to products? $A \rightarrow B$

A) Rate remains the same and half-life decreases.
B) Rate decreases and half-life remains the same.
C) Rate and half-life both decrease.
D) Rate and half-life both increase.
E) Rate decreases as half-life increases.

60. The data in the table of initial rates show that the rate law for the reaction $A \rightarrow B$ is:

| Experiment | [A] | [B] | Rate (M/s) |
|---|---|---|---|
| 1 | 0.10 | 0.10 | 1 |
| 2 | 0.10 | 0.20 | 2 |
| 3 | 0.20 | 0.40 | 16 |

A) Rate$=k[A][B]$
B) Rate$=k[A][B]^2$
C) Rate$=k[A]^2[B]$
D) Rate$=k[A]^2[B]^2$
E) Rate$=k[A]^0[B]^2$