

Contents: ACS Final Exam Review

General Chemistry Cumulative Review.

Concept Review (Pages 1-3)

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Concept Review

Your Gen Chem “ABC’s”.

For each term or concept, please write in your own words its conceptual definition or significance. This should mostly be written words, but you may also use equations or variables to help with your understanding 😊

Activation energy

Angular momentum quantum number

Atomic Radius (trend)

Aufbau Principle

Bohr Model of an Atom

Buffers

Collision model

Colligative properties

Covalent Bond

Crystal field theory

De Broglie Wavelength

Equilibrium

Electronegativity (and trends)

Endo/exothermic

Enthalpy

Entropy

Frequency Factor

Gibb's Free Energy

Heat capacity

Heisenberg uncertainty principle

Hybridization

Ionization Energy

Intermolecular Force

Intramolecular force

Ionic Bond

Kinetics

Kinetic molecular theory

LeChatelier Principle

Lewis Acid/Base

Magnetic quantum number

Molecular orbital theory

Net ionic reaction

Molality

Molarity

Oxidation-reduction

Pauli Exclusion Principle

Photoelectric effect

Principle quantum number

precipitate

Real vs ideal gas

Rate law

Resonance

Spectrochemical series

Spin quantum number

Transition state

Titration

Theoretical Yield

Unit Cell

Valence bond theory

Van Der Waal Equation for Gas

Van Hoff Factor

$Z_{\text{eff}}$  Effective Nuclear Charge

### **Know the Laws!**

Avogadro's Law

Boyle's Law

Charles' Law

Dalton's Law

Hund's Law

Ideal Gas Law

Law of Conservation of Mass

Law of multiple proportions

0<sup>th</sup> law of thermodynamics

1<sup>st</sup> law of thermodynamics

2<sup>nd</sup> law of thermodynamics

3<sup>rd</sup> law of thermodynamics

Raoult's Law

Bragg's Law

Hess's Law

Practice test 1: Taken from an ACS General Chemistry Prep Book. Questions are a lot easier than the actual test! Use this for practice. Answer key at the end.

1. Which of the following is an example of a Brønsted-Lowry base in water?
  - a.  $\text{H}_3\text{O}^+$
  - b.  $\text{CO}_2$
  - c.  $\text{NH}_3$
  - d.  $\text{HCl}$
2. What is the electrical charge of the nucleus?
  - a. A nucleus always has a positive charge.
  - b. A stable nucleus has a positive charge, but a radioactive nucleus may have no charge and instead be neutral.
  - c. A nucleus always has no charge and is instead neutral.
  - d. A stable nucleus has no charge and is instead neutral, but a radioactive nucleus may have a charge.
3. What is the temperature in Fahrenheit when it is 35 °C outside?
  - a. 67 °F
  - b. 95 °F
  - c. 63 °F
  - d. 75 °F
4. How are a sodium atom and a sodium isotope different?
  - a. The isotope has a different number of protons.
  - b. The isotope has a different number of neutrons.
  - c. The isotope has a different number of electrons.
  - d. The isotope has a different atomic number.
5. Which statement is TRUE about nonmetals?
  - a. They form cations.
  - b. They form covalent bonds.
  - c. They are mostly absent from organic compounds.
  - d. They are all diatomic.
6. What is the basic unit of matter?
  - a. Elementary particle
  - b. Atom
  - c. Molecule
  - d. Photon
7. Which particle is responsible for all chemical reactions?
  - a. Electron
  - b. Neutron
  - c. Proton
  - d. Orbital

8. Which of these give atoms a negative charge?
- a. Electrons
  - b. Neutrons
  - c. Protons
  - d. Orbital
9. How are similar chemical properties of elements grouped on the periodic table?
- a. In rows according to their total configuration of electrons
  - b. In columns according to the electron configuration in their outer shells
  - c. In rows according to the electron configuration in their outer shells
  - d. In columns according to their total configurations of electrons
10. In a chemical equation, the reactants are on which side of the arrow?
- a. Right
  - b. Left
  - c. Neither right nor left
  - d. Both right and left
11. What does the law of conservation of mass state?
- a. All matter is equally created.
  - b. Matter changes but is not created.
  - c. Matter can be changed, and new matter can be created
  - d. Matter can be created, but not changed.
12. Which factors decrease solubility of solids?
- a. Heating
  - b. Agitation
  - c. Large surface area
  - d. Decreasing solvent
13. What information is used to calculate the quantity of solute in a solution?
- a. Molarity of the solution
  - b. Equivalence point
  - c. Limiting reactant
  - d. Theoretical yield
14. How does adding salt to water affect its boiling point?
- a. It increases it.
  - b. It has no effect.
  - c. It decreases it.
  - d. It prevents it from boiling.
15. What is the effect of pressure on a liquid solution?
- a. It decreases solubility.
  - b. It increases solubility.
  - c. It has little effect on solubility.
  - d. It has the same effect as with a gaseous solution.

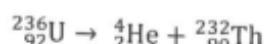
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16. Nonpolar molecules must have what kind of regions?
- a. Hydrophilic
  - b. Hydrophobic
  - c. Hydrolytic
  - d. Hydrochloric
17. Which of these is a substance that increases the rate of a chemical reaction?
- a. Catalyst
  - b. Helium
  - c. Solvent
  - d. Inhibitor
18. If sodium hydroxide (NaOH) is added to a dilute solution of potassium hydroxide (KOH), how will the NaOH equilibrium be affected, compared to NaOH dissolved in pure water?
- a. Sodium hydroxide always dissociates completely to form more ions.
  - b. The equilibrium of sodium hydroxide is unaffected by KOH.
  - c. The equilibrium of the reaction favors sodium hydroxide.
  - d. Sodium hydroxide does not dissociate in the KOH solution.
19. What coefficients are needed to balance the following combustion equation?
- $$-\text{C}_2\text{H}_{10} + -\text{O}_2 \rightarrow -\text{H}_2\text{O} + -\text{CO}_2$$
- a. 1:5:5:2
  - b. 1:9:5:2
  - c. 2:9:10:4
  - d. 2:5:10:4
20. Which type of bonding results from transferring electrons between atoms?
- a. Ionic bonding
  - b. Covalent bonding
  - c. Hydrogen bonding
  - d. Dipole interactions
21. Which substance is oxidized in the following reaction?
- $$4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3$$
- a. Fe
  - b. O
  - c. O<sub>2</sub>
  - d. Fe<sub>2</sub>O<sub>3</sub>

22. Which statements are true regarding nuclear fission?

- I. Splitting of heavy nuclei
- II. Utilized in power plants
- III. Occurs on the sun

- a. Choice I only
- b. Choices II and III
- c. Choices I and II
- d. Choice III only

23. Which type of nuclear decay is occurring in the equation below?



- a. Alpha
- b. Beta
- c. Gamma
- d. Delta

24. Which statement is true about the pH of a solution?

- a. A solution cannot have a pH less than 1.
- b. The more hydroxide ions there are in the solution, the higher the pH will be.
- c. If an acid has a pH of greater than -1, it is considered a weak acid.
- d. A solution with a pH of 2 has ten times the amount of hydronium ions than a solution with a pH of 1.

25. Which radioactive particle is the MOST penetrating and damaging and is used to treat cancer in radiation?

- a. Alpha
- b. Beta
- c. Gamma
- d. Delta

26. An atom of radium-226,  ${}^{226}_{88}\text{Ra}$ , contains:

- a. 88 neutrons, 138 protons, and 226 electrons
- b. 88 protons, 138 electrons, and 226 neutrons
- c. 88 protons, 88 electrons, and 138 neutrons
- d. 88 electrons, 88 protons, and 226 neutrons

27. Which of the following sets of quantum numbers is INCORRECT?

- a.  $n = 2, l = 1, m_l = +1$
- b.  $n = 2, l = 1, m_l = 0$
- c.  $n = 1, l = 0, m_l = 0$
- d.  $n = 3, l = 1, m_l = -2$

28. Suppose that you exhale half a liter (0.500 L) of carbon dioxide ( $\text{CO}_2$ ) gas into a balloon. How many oxygen atoms are present inside the balloon if the oxygen atoms come from carbon dioxide? The molar volume of carbon dioxide is 22.4 L/mol.

- a.  $1.34 \times 10^{22}$  O atoms
- b.  $2.69 \times 10^{22}$   $\text{O}_2$  atoms
- c.  $2.69 \times 10^{22}$  O atoms
- d.  $1.34 \times 10^{22}$   $\text{O}_2$  atoms

29. The caffeine molecule, found in coffee and tea, has a molecular formula of  $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$ . What is the mass in kilograms for one molecule of caffeine?

- a.  $3 \times 10^{-25}$  kg
- b.  $4 \times 10^{-25}$  kg
- c.  $3 \times 10^{-22}$  kg
- d.  $1 \times 10^{-22}$  kg

30. If a compound containing nitrogen and oxygen weighs a total of 2.04 g, what is the empirical formula if the substance contains 1.51 g of oxygen?

- a.  $\text{N}_2\text{O}_5$
- b.  $\text{N}_2\text{O}$
- c. NO
- d.  $\text{NO}_2$

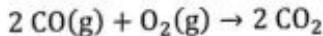
31. A compound containing sulfur and oxygen has the empirical formula of  $\text{SO}_2$ . If 0.162 grams of the actual compound,  $(\text{SO}_2)_n$ , contains  $7.61 \times 10^{20}$  molecules, what must the value of  $n$  be?

- a. 4
- b. 3
- c. 2
- d. 1

32. Find the mass of oxygen present in 1.50 mole of sucrose ( $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ).

- a. 195 g
- b. 200 g
- c. 245 g
- d. 264 g

33. Carbon dioxide can be prepared by the reaction or combustion of carbon monoxide and oxygen:



If three moles of carbon monoxide react with one mole of oxygen gas, the amount of carbon dioxide that is produced is called the:

- a. Product yield
- b. Theoretical yield
- c. Limiting reactant
- d. Excess reactant

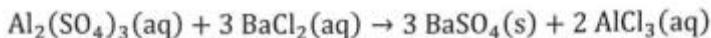
34. If carbon dioxide is passed over charcoal, it will produce carbon monoxide:



Suppose two moles of carbon dioxide react with three moles of carbon to produce a theoretical amount of carbon monoxide. If the excess reactant is consumed or depleted, how many more moles of carbon monoxide could be produced?

- a. 2 moles
- b. 3 moles
- c. 4 moles
- d. 5 moles

35. If 3.52 g of aluminum sulfate is mixed with 4.06 g of barium chloride in solution, what is the theoretical yield of barium sulfate (molar mass is 233.40 g/mol)?



- a. 3.15 g  $\text{BaSO}_4$
- b. 1.95 g  $\text{BaSO}_4$
- c. 3.09 g  $\text{BaSO}_4$
- d. 4.55 g  $\text{BaSO}_4$

36. If 3.96 grams of barium sulfate is collected through a separate filtration process, what is the percent yield for a mixture of aluminum sulfate and barium chloride that had a theoretical yield of 4.21 g?

- a. 106 percent
- b. 0.94
- c. 94 percent
- d. 1.06

37. How many grams of excess reactant is present if 3.52 g of aluminum sulfate is mixed with 4.06 grams of barium chloride?

- a. 2.00 g  $\text{Al}_2(\text{SO}_4)_3$
- b. 0.50 g  $\text{Al}_2(\text{SO}_4)_3$
- c. 1.30 g  $\text{Al}_2(\text{SO}_4)_3$
- d. 2.50 g  $\text{Al}_2(\text{SO}_4)_3$

38. If 100 mL of 0.050 M  $\text{AgNO}_3$  is added to 50.0 mL of 0.050 M  $\text{Na}_2\text{SO}_4$ , which of the following choices is true? Note that  $K_{\text{sp}}$  of  $\text{Ag}_2\text{SO}_4$  is  $6.9 \times 10^{-15}$ .

- a. A precipitate will form without any excess ions.
- b. A precipitate will form with excess  $\text{Ag}^+$ .
- c. There will be no precipitate.
- d. A precipitate will form with an excess of  $\text{Ag}^+$  and  $\text{SO}_4^{2-}$ .

39. A common way to express the concentration of a solution is in units of moles per liter, which is called the:

- a. Molality
- b. Molarity
- c. Molar volume
- d. Parts per mass

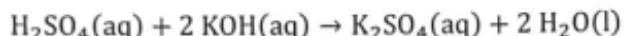
40. What mass of water is needed to dissolve 250.0 g of AgCl to make a 0.35 mol/kg AgCl aqueous solution?

- a. 5.0 kg
- b. 1.7 moles per liter
- c. 5.0 moles per liter
- d. 1.7 kg

41. What volume of a 5.00 M HNO<sub>3</sub> solution is needed to make 350 mL of a 2.00 M HNO<sub>3</sub> solution? What volume of 5.00 M HNO<sub>3</sub> should be added to water to make the 2.00 M HNO<sub>3</sub> solution?

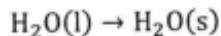
- a. Take 350 mL of water and add 140 mL the concentrated acid.
- b. Take 210 mL of water and add 140 mL the concentrated acid.
- c. Take 350 L of water and add 140 L the concentrated acid.
- d. Take 210 L of water and add 140 L the concentrated acid.

42. During an acid-base titration experiment, the endpoint was reached when 35.00 mL of a standardized 1.500 M potassium hydroxide was added to a 15.00 mL solution of sulfuric acid. What is the concentration of the acid assuming that the endpoint is near the equivalence point? The reaction of sulfuric acid and potassium hydroxide is shown below:



- a. 0.5250 M H<sub>2</sub>SO<sub>4</sub>
- b. 0.750 M H<sub>2</sub>SO<sub>4</sub>
- c. 1.750 M H<sub>2</sub>SO<sub>4</sub>
- d. 3.500 M H<sub>2</sub>SO<sub>4</sub>

43. In anticipation of freezing weather, farmers may spray water over their plants and cover them with large plastic materials. As the temperature drops below 0 °C (32 °F), the following physical process will occur for the water found on the plants:



If water is treated as the chemical system, which of the following is correct?

- a. The process is exothermic and  $+q_{\text{system}} = -q_{\text{surroundings}}$ .
- b. The process is endothermic and  $+q_{\text{system}} = +q_{\text{surroundings}}$ .
- c. The process is exothermic and  $-q_{\text{system}} = +q_{\text{surroundings}}$ .
- d. The process is endothermic and  $-q_{\text{system}} = +q_{\text{surroundings}}$ .

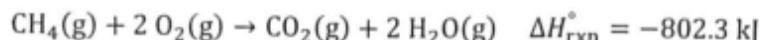
44. The standard enthalpies of formation for lithium bromide and lithium chloride are shown below.

Standard enthalpies of formation at 298K, $\Delta H_f^\circ$ (kJ/mol)	
LiBr	-351.2
LiCl	-408.6

Which of the following statements is true?

- a.  $\Delta H_f^\circ$  for LiCl is less exothermic than  $\Delta H_f^\circ$  for LiBr
- b.  $\Delta H_f^\circ$  for LiCl is more exothermic than  $\Delta H_f^\circ$  for LiBr
- c.  $\Delta H_f^\circ$  for LiCl is more endothermic than  $\Delta H_f^\circ$  for LiBr
- d.  $\Delta H_f^\circ$  for LiCl is less endothermic than  $\Delta H_f^\circ$  for LiBr

45. The combustion of one mole of methane produces carbon dioxide and water with an amount of heat (in kJ) shown in the following thermochemical equation:



How much heat is produced if 1.5 kg of methane is combusted in oxygen gas?

- a.  $-7.50 \times 10^4 \text{ kJ/mol}$
- b.  $+7.50 \times 10^4 \text{ kJ/mol}$
- c.  $+7.50 \times 10^4 \text{ kJ}$
- d.  $-7.50 \times 10^4 \text{ kJ}$

46. For the reaction shown below, calculate the standard enthalpy of reaction  $\Delta H_{\text{rxn}}^\circ$  using the standard enthalpies of formation shown in the table below.



Standard enthalpies of formation at 298K, $\Delta H_f^\circ$ (kJ/mol)	
Al(s)	0
Fe <sub>2</sub> O <sub>3</sub> (s)	-824.2
Al <sub>2</sub> O <sub>3</sub> (s)	-1675.7
Fe(s)	0

- a. -851.5 kJ
- b. -2499.9 kJ
- c. +851.5 kJ
- d. +2499.9 kJ

47. A 43.0 g metal sample at a temperature of 100.0 °C is dropped into a 100.0 mL water bath with an initial temperature of 25.0 °C. The temperature of the water bath increased to a final temperature of 37.0 °C. What is the specific heat of the metal if the specific heat capacity of water is 4.184 J/(g °C)? The density of water is about 1 g/mL.

- a. 2.95 J/(g °C)
- b. 0.87 J/(g °C)
- c. 1.85 J/(g °C)
- d. 4.25 J/(g °C)

48. Which of the following processes involves an increase in entropy?

- a. The contraction of a gas.
- b. The freezing of water:  $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{s})$
- c.  $\text{CaO}(\text{s}) + \text{CO}_2(\text{g}) \rightarrow \text{CaCO}_3(\text{s})$
- d. Adding sugar to water:  $\text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{s}) \xrightarrow{\text{H}_2\text{O}(\text{l})} \text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{aq})$

49. The following equation gives the Gibbs free energy  $\Delta G$  for a chemical reaction:

$$\Delta G = \Delta H - T\Delta S$$

If the Gibbs free energy of the system is negative, the reaction is spontaneous. If it is positive, the reaction is not spontaneous and will occur. If the free energy is zero, then the reaction is at equilibrium. Which of the following is true if both  $\Delta H$  and  $\Delta S$  are positive?

- a. The reaction is spontaneous when the temperature is increased.
- b. The reaction is spontaneous at any temperature.
- c. The reaction is spontaneous when the temperature is decreased.
- d. The reaction is nonspontaneous at any temperature.

50. Consider the following hypothetical reaction:



At what conditions would this reaction be spontaneous? What is the sign of  $\Delta S_{rxn}^\circ$ ?

- a. Spontaneous at low temperatures and  $+\Delta S_{rxn}^\circ$
- b. Spontaneous at high temperatures and  $+\Delta S_{rxn}^\circ$
- c. Spontaneous at low temperatures and  $-\Delta S_{rxn}^\circ$
- d. Spontaneous at high temperatures and  $+\Delta S_{rxn}^\circ$

51. How many electrons are in the p subshell for the nitrogen atom?

- a. 2
- b. 3
- c. 4
- d. 5

52. Based on the Aufbau principle, which of the following choices most likely represents the set of quantum numbers corresponding to the eighth electron in the oxygen atom?

- a.  $n = 2, l = 0, m_l = 0, m_s = +1/2$
- b.  $n = 2, l = 1, m_l = -1, m_s = +1/2$
- c.  $n = 2, l = 0, m_l = 0, m_s = -1/2$
- d.  $n = 2, l = 1, m_l = -1, m_s = -1/2$

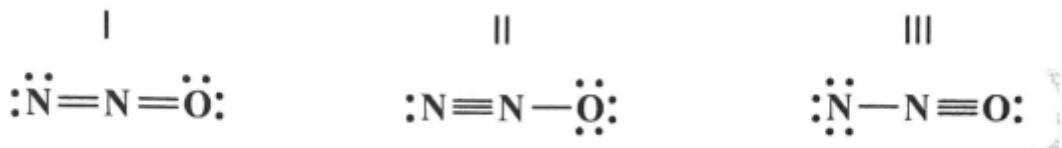
53. Which of the following quantum numbers does not represent an electron in the nitrogen atom?

- a.  $n = 2, l = 1, m_l = -2, m_s = -1/2$
- b.  $n = 1, l = 0, m_l = 0, m_s = -1/2$
- c.  $n = 2, l = 0, m_l = 0, m_s = -1/2$
- d.  $n = 2, l = 1, m_l = -1, m_s = +1/2$

54. What is the electron group geometry of the  $\text{NF}_3$  molecule?

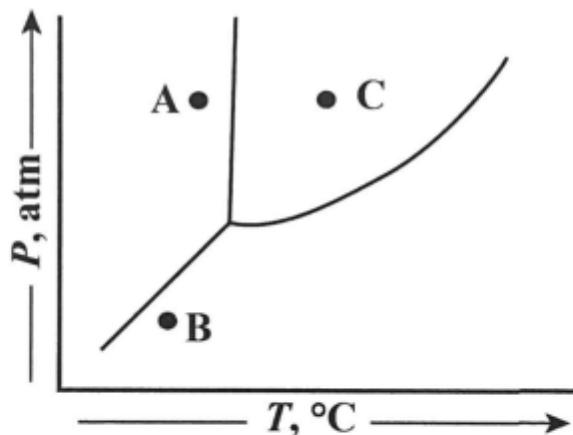
- a. Trigonal planar
- b. Tetrahedral
- c. Trigonal bipyramidal
- d. Octahedral

55. For the three structures below, which Lewis structure for nitrous oxide ( $N_2O$ ) is the most likely the correct structure? Choose the right answer choice below which has the correct corresponding formal charges for the N, N, and O atoms.



- a. Structure 1, formal charges are  $-1, +1, 0$
- b. Structure 2, formal charges are  $0, +1, -1$
- c. Structure 3, formal charges are  $-2, +1, +1$
- d. Structure 1, formal charges are  $+2, +1, 0$

56. Which of the following statements is NOT true regarding the phase diagram below.



- a. If a compound is in state A, with the temperature held constant, reducing the pressure will cause it to sublime.
- b. Decreasing the pressure and temperature from point C to point B represents evaporation.
- c. The slope of the solid and liquid equilibrium line is positive, similar to the phase diagram of water.
- d. Increasing the temperature from point A to point C represents melting.

57. The vapor pressure of a solution is lowered when a nonvolatile solute is added to a pure solvent. As a result, the freezing point for the solution decreases, and the boiling point increases. The following equation gives the freezing point depression:

$$\Delta T_f = m \times K_f$$

The term  $\Delta T_f = T_{\text{solvent}} - T_{\text{solution}}$  represents the temperature change or freezing point depression in degrees Celsius, and the terms  $m$  and  $K_f$  are the molality (units of molal or mol/kg) and freezing point depression constant for the solvent (units of  $\frac{\text{°C}}{\text{mol kg}^{-1}}$ ). If  $1.00 \times 10^3$  g of ethylene glycol ( $\text{C}_2\text{H}_6\text{O}_2$ , molar mass = 62.07 g/mol) is added to a radiator that contains  $5.00 \times 10^3$  g of water, how much would the freezing point lower? Note that  $K_f = 1.86 \text{ °C}/(\text{mol kg}^{-1})$ .

- a.  $-5.99 \text{ °C}$
- b.  $+5.99 \text{ °C}$
- c.  $-3.22 \text{ °C}$
- d.  $+3.22 \text{ °C}$

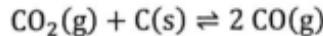
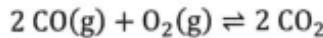
58. The activation energy for a chemical reaction involving the breakage of a carbon-oxygen single bond was estimated at 125 kJ/mol at  $25.0 \text{ °C}$ . If the temperature is increased to about  $50.0 \text{ °C}$ , by what factor does the rate constant increase?

- a. 10.5
- b. 32.1
- c. 49.5
- d. 29.6

59. The half-life for an unknown element called X is 7.95 days. How many days would this sample need to reach 35.0 percent of its original amount?

- a. 19.5 days
- b. 12.0 days
- c. 11.5 days
- d. 15.0 days

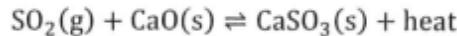
60. Consider the following two-step reaction below:



What is the overall equilibrium expression?

- a.  $K_{\text{overall}} = \frac{[\text{CO}_2]^2}{[\text{CO}]^2[\text{O}_2]}$
- b.  $K_{\text{overall}} = \frac{[\text{CO}]^2}{[\text{CO}_2][\text{C}]}$
- c.  $K_{\text{overall}} = \frac{[\text{CO}_2]^2}{[\text{O}_2][\text{C}]}$
- d.  $K_{\text{overall}} = \frac{[\text{CO}_2]}{[\text{O}_2][\text{C}]}$

61. Consider the following exothermic reaction:



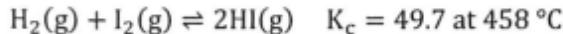
Which of the following changes will result in a decrease in pressure of  $\text{SO}_2(\text{g})$  at equilibrium?

- a. Addition of  $\text{CaO}(\text{s})$
- b. Removal of  $\text{CaSO}_3(\text{s})$
- c. Increasing the volume of the reaction vessel
- d. Decreasing the temperature of the chemical reaction system

62. What is the pH of a 0.35 M solution of ammonia in water? Note that  $K_b = 1.8 \times 10^{-5}$

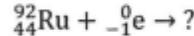
- a. 10.20
- b. 8.01
- c. 11.25
- d. 8.96

63. What is the equilibrium concentration of a reaction mixture that initially had 1.00 mol  $\text{H}_2$  and 1.00 mol  $\text{I}_2$  in a 1.0 L vessel?



- a.  $[\text{H}_2] = [\text{I}_2] = 0.22 \text{ M}$ ,  $[\text{HI}] = 1.6 \text{ M}$
- b.  $[\text{H}_2] = [\text{I}_2] = 0.33 \text{ M}$ ,  $[\text{HI}] = 1.8 \text{ M}$
- c.  $[\text{H}_2] = [\text{I}_2] = 0.44 \text{ M}$ ,  $[\text{HI}] = 2.0 \text{ M}$
- d.  $[\text{H}_2] = [\text{I}_2] = 0.55 \text{ M}$ ,  $[\text{HI}] = 2.2 \text{ M}$

64. For the following radioactive decay process, which of the following is the correct product shown in the nuclear equation below?

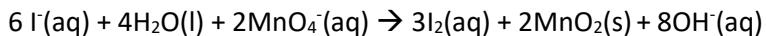


- a.  ${}_{45}^{92}\text{Rh}$
- b.  ${}_{43}^{92}\text{Rh}$
- c.  ${}_{43}^{92}\text{Tc}$
- d.  ${}_{2}^{4}\text{He} + {}_{43}^{92}\text{Tc}$

65. Find the N/Z ratio of Pb-212 to predict whether beta decay or positron emission will occur, and then determine which choice below represents the N/Z ratio of the daughter nuclide.

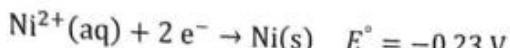
- a. 1.59
- b. 1.55
- c. 1.41
- d. 1.37

66. For the following redox reaction, which of the following statements is true?



- a.  $\text{MnO}_4^-$  is oxidized in the reaction.
- b.  $\text{MnO}_4^-$  is the oxidizing agent.
- c.  $\text{I}^-$  is reduced in the reaction.
- d.  $\text{I}^-$  is the oxidizing agent.

67. Consider the standard reduction potentials for the reactions shown below. Calculate the standard cell potential,  $E_{\text{cell}}^\circ$ , for the spontaneous reaction.



- a.  $E_{\text{cell}}^\circ = -1.43 \text{ V}$
- b.  $E_{\text{cell}}^\circ = +1.43 \text{ V}$
- c.  $E_{\text{cell}}^\circ = -2.63 \text{ V}$
- d.  $E_{\text{cell}}^\circ = +2.63 \text{ V}$

68. The solubility of silver chloride ( $\text{AgCl}$ ) is approximately  $1.9 \times 10^{-3}$  g/L in water. Which of the following choices below most closely corresponds to the correct solubility product constant ( $K_{\text{sp}}$ )?

- a.  $1.6 \times 10^{-10}$
- b.  $1.8 \times 10^{-10}$
- c.  $2.0 \times 10^{-10}$
- d.  $3.6 \times 10^{-10}$

69. Which of the following choices is NOT true regarding the equilibrium constant.

- a. It can be used to predict the extent of the reaction.
- b. It gives information on the direction of the reaction.
- c. It can be used to determine the time needed to reach equilibrium.
- d. It can be used to help calculate equilibrium concentrations.

70. Which of the following is equivalent to 1000ppms (parts per millions)?

- a. 1 mg NaCl in 1 L  $\text{H}_2\text{O}$
- b. 10mg NaCl in 1mL  $\text{H}_2\text{O}$
- c. 1 mg NaCl in 10 mL  $\text{H}_2\text{O}$
- d. 100mg NaCl in 1 L  $\text{H}_2\text{O}$

### Practice Test 1 Answer Key

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

Practice test 2: Unofficial ACS Practice test. A little harder than the last, easier than expected test. Questions are sorted by topic and there are 80 questions instead of 70. Also use this for learning material. Answer key is at the end

**Acids & Bases:**

1. All are examples of Lewis acid–base reactions *except*

- (A)  $\text{Cu}^{2+}(aq) + 4\text{NH}_3(aq) \rightleftharpoons [\text{Cu}(\text{NH}_3)_4]^{2+}(aq)$   
(B)  $\text{HCl}_{(g)} + \text{NH}_3(g) \rightarrow \text{NH}_4\text{Cl}_{(s)}$   
(C)  $\text{H}^{+}(aq) + \text{OH}^{-}(aq) \rightleftharpoons \text{H}_2\text{O}_{(l)}$   
(D)  $2\text{Na}_{(s)} + \text{Cl}_2(g) \rightarrow 2\text{NaCl}_{(s)}$

2. According to the Lewis definition, an acid is a species

- (A) having a hydrogen ion. (B) donating a pair of electrons.  
(C) accepting a pair of electrons. (D) accepting a hydrogen ion.

3. All are potential Lewis bases *except*

- (A)  $\text{NH}_3$  (B)  $\text{H}_2\text{O}$  (C)  $\text{CH}_4$  (D)  $\text{CN}^-$

4. Which hydrated metal ion is most acidic under conditions of equal molar concentration in water?

- (A)  $\text{Al}^{3+}$  (B)  $\text{Ba}^{2+}$  (C)  $\text{K}^+$  (D)  $\text{Zn}^{2+}$  (E)  $\text{Ag}^+$

5. Which element in Group 5A forms the most basic oxide?

- (A) N (B) P (C) As (D) Sb (E) Bi

**Atomic Structure:**

6. In what respect does an atom of magnesium differ from a magnesium ion ( $\text{Mg}^{2+}$ )?

- (A) The ion has a more stable electronic arrangement than the atom.  
(B) The positive charge on the nucleus of the ion is two units greater than the nuclear charge on the atom.  
(C) The ion has two more protons than the atom.  
(D) The ion will react more readily with free  $\text{Cl}_2$ .  
(E) The ion has two more planetary electrons than the atom.

7. A certain atom has the symbol  $^{148}_{73}\text{Px}$ . What does this symbol tell about an atom of the element?

- (A) It has 148 electrons. (B) It has a valence of 4.  
(C) It has 221 protons in the nucleus. (D) It has 75 neutrons in the nucleus.  
(E) Its atomic mass is 73 u.

8. The atomic mass of an element is 32.07 u and its atomic number is 16. The number of protons contained in the nucleus of an atom of this element is

- (A) 16 (B) 31 (C) 32 (D) 48

9. The atomic mass of an element is 32.07 u and its atomic number is 16. The element forms a simple ion. The ion will most likely have a charge of

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

10. The nucleus of which atom contains seven neutrons?

Atom A	n = 1	n = 2	n = 3
M = 24, Z = 12	2e	8e	2e

Atom B	n = 1	n = 2	n = 3
M = 15, Z = 7	2e	5e	

Atom C	n = 1	n = 2	n = 3
M = 17, Z = 10	2e	8e	

Atom D	n = 1	n = 2	n = 3
M = 7, Z = 3	2e	1e	

Atom E	n = 1	n = 2	n = 3
M = 34, Z = 17	2e	8e	7e

- (A) A (B) B (C) C (D) D (E) E

**Bonding:**

11. In which pair of compounds should the first member be more covalent than the second member?

- (A) TlCl, TlCl<sub>3</sub> (B) SnI<sub>4</sub>, SnF<sub>4</sub> (C) LiF, BF<sub>3</sub> (D) SnF<sub>4</sub>, CF<sub>4</sub>

12. Which is the most complete and best description of a covalent bond?

- (A) a system of two nuclei with a pair of electrons located exactly midway between both nuclei  
(B) the attractive force between two atoms of opposite charge  
(C) a donor bond in which one atom donates an unshared pair to the other  
(D) a system of two nuclei where each atom donates one electron to the other atom, thus forming a bond

13. Which pair of elements is most likely to react to form a covalently bonded species?

- (A) P and O (B) Ca and O (C) K and S (D) Zn and C

14. Which chloride should exhibit the most covalent type of bond?

- (A) NaCl (B) KCl (C) CaCl<sub>2</sub> (D) BaCl<sub>2</sub> (E) BeCl<sub>2</sub>

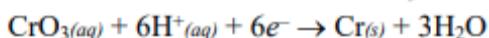
15. The compound of which two elements is most likely to involve covalent bonding?

Electronegativities of Unknown Elements			
Q	0.9	X	3.0
R	1.0	Z	4.0
T	2.8		

- (A) Q and Z (B) R and T (C) T and X (D) R and X (E) R and Z

**Electrochemistry:**

16. Chromium metal can be plated from an acidic solution of CrO<sub>3</sub>.

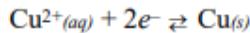


How many grams of chromium will be plated by the passage of 19,300 C (coulombs)?

- (A) 10.4 (B) 5.19 (C) 1.73 (D) 0.20

17. What time is required to plate 2.08 g of copper at a constant current flow of 1.26 A?

Atomic Molar Mass	
Cu	63.5 g·mol <sup>-1</sup>



- (A) 41.8 min (B) 83.6 min (C) 128 min (D) 4820 min

18. Nickel is a transition element and has a variable valence. Using a nickel salt, 2 F (faradays) plate out 39.2 g of nickel. What ions are in the solution of this salt?

Atomic Molar Mass	
Ni	58.7 g·mol <sup>-1</sup>

- (A) Ni<sup>+</sup> (B) Ni<sup>2+</sup> (C) Ni<sup>3+</sup> (D) Ni<sup>2/3+</sup>

19. A given amount of electric charge deposits 2.159 g of silver from an Ag<sup>+</sup> solution. What mass of copper from a Cu<sup>2+</sup> solution will be deposited by the same quantity of electric charge?

Atomic Molar Masses	
Ag	107.9 g·mol <sup>-1</sup>
Cu	63.5 g·mol <sup>-1</sup>

- (A) 0.635 g (B) 1.97 g (C) 2.54 g (D) 127 g

20. If each of these ions were reduced to metal with one coulomb, which would yield the greatest mass?

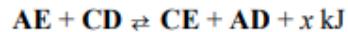
- (A) Cu<sup>2+)(aq</sup> (B) Ag<sup>+(aq)</sup> (C) Hg<sup>2+)(aq</sup> (D) Cu<sup>+(aq)</sup>

**Equilibrium:**

21. Which is a proper description of chemical equilibrium?

- (A) The frequencies of reactant and of product collisions are identical.  
(B) The concentrations of products and reactants are identical.  
(C) The velocities of product and reactant molecules are identical.  
(D) Reactant molecules are forming products as fast as product molecules are reacting to form reactants.  
(E) The numbers of moles of reactants and products are equal.

22. When equilibrium has been reached in the reaction



in which all substances are in solution,

- (A) adding AE will increase the concentration of CE but not of AD.  
(B) adding CD will increase the concentration of both AE and AD.  
(C) heating will increase the concentration of both AE and CE.  
(D) escape of some AD by volatilization will increase the concentration of CE.  
(E) doubling the pressure will increase the concentration of CE.

23. Given the reaction  $2\text{X}_{(g)} + \text{Y}_{(g)} \rightleftharpoons 2\text{Z}_{(g)}$   $\Delta H = -335 \text{ kJ}$  which combination of pressure and temperature gives the highest yield of Z at equilibrium?

- (A) 1000 atm and 500 °C (B) 500 atm and 500 °C  
(C) 1000 atm and 100 °C (D) 500 atm and 100 °C  
(E) catalyst, 500 atm and 100 °C

24. The reaction for the formation of ammonia by direct combination is



Which operation will increase the yield of ammonia in the equilibrium mixture?

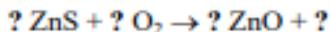
- (A) doubling the concentration of hydrogen      (B) reducing the total pressure  
(C) raising the temperature      (D) increasing the reaction time  
(E) adding a catalyst

25. Chemical equilibrium is the **result** of

- (A) a decrease in speed of reaction.  
(B) the unavailability of one of the reactants.  
(C) a stoppage of further reaction.  
(D) opposing reactions attaining equal speeds.  
(E) formation of products equal in mass to the reactants.

**Formulas & Equations:**

26. Complete and balance the equation for the combustion of ZnS in excess oxygen



Use no fractional coefficients. The number of moles and the formula of the product containing S are

- (A) 2S      (B) S<sub>8</sub>      (C) SO<sub>2</sub>      (D) 2SO<sub>2</sub>      (E) SO<sub>3</sub>

27. Balance the equation for the reaction, using no fractional coefficients.



The ratio of the moles of oxidizing agent to moles of reducing agent in the balanced equation is

- (A) 5 to 2. (B) 5 to 3. (C) 3 to 5. (D) 2 to 5. (E) 1 to 1.

28. Balance the equation for the reaction, using no fractional coefficients.



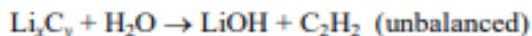
The coefficient of KOH in the balanced equation is

- (A) 2      (B) 4      (C) 6      (D) 8      (E) 10

29. Why is the equation incorrect?      Mg<sub>3</sub> + N<sub>2</sub> → Mg<sub>3</sub>N<sub>2</sub>

- (A) Some of the subscripts are incorrectly used.  
(B) The equation is not balanced.  
(C) The valence of the nitride ion is incorrect.  
(D) The valence of the magnesium ion is incorrect.  
(E) The coefficient of N<sub>2</sub> is incorrect.

30. A lithium carbide (Li<sub>x</sub>C<sub>y</sub>) reacts with water as follows:



What is the simplest formula of the carbide?

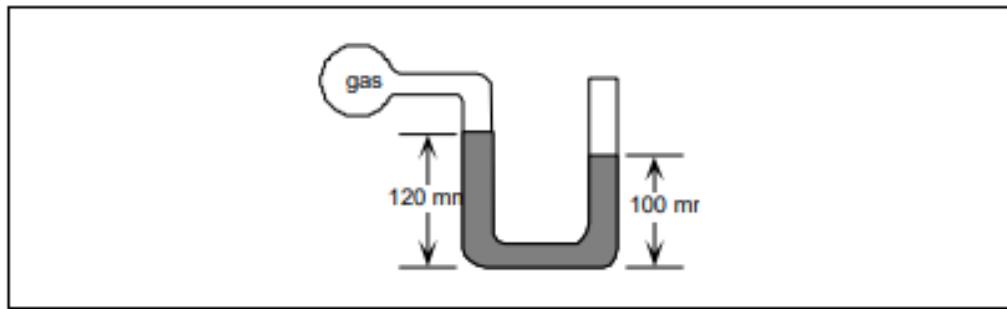
- (A) LiC      (B) Li<sub>2</sub>C      (C) LiC<sub>2</sub>      (D) Li<sub>3</sub>C<sub>4</sub>

**Gases:**

31. In which gas are the forces between molecules strongest?

- (A) Ne      (B) CH<sub>4</sub>      (C) O<sub>2</sub>      (D) H<sub>2</sub>O

32. The density of a gas is  $1.96 \text{ g L}^{-1}$  at  $1.00 \text{ atm}$  and  $0^\circ\text{C}$ . What is the density of this gas at  $0.855 \text{ atm}$  and  $25.0^\circ\text{C}$ ?  
(A)  $0.00276 \text{ g L}^{-1}$     (B)  $0.651 \text{ g L}^{-1}$     (C)  $1.54 \text{ g L}^{-1}$     (D)  $1.82 \text{ g L}^{-1}$
33. A  $1200 \text{ mL}$  sample of helium gas is at a pressure of  $350 \text{ mmHg}$  and a temperature of  $300 \text{ K}$ . What volume will this gas sample occupy if the pressure is increased to  $700 \text{ mmHg}$  and the temperature is increased to  $400 \text{ K}$ ?  
(A)  $450 \text{ mL}$     (B)  $800 \text{ mL}$     (C)  $1650 \text{ mL}$     (D)  $3200 \text{ mL}$
34. The height of the mercury in the right arm open to atmospheric pressure ( $760 \text{ mmHg}$ ) is  $100 \text{ mm}$  and the height in the left arm is  $120 \text{ mm}$ .



- What is the pressure of the gas in the bulb?  
(A)  $20 \text{ mmHg}$     (B)  $640 \text{ mmHg}$     (C)  $740 \text{ mmHg}$     (D)  $780 \text{ mmHg}$
35. A sample of nitrogen at pressure  $P$  is contained in a sealed syringe with a movable piston. If the volume of the sample were doubled and the absolute temperature tripled, the new pressure of the gas would be  
(A)  $6.0P$     (B)  $5.0P$     (C)  $3.5P$     (D)  $1.5P$
- Introductory Concepts:**
36. When equal volumes of  $0.1 \text{ M}$  solutions of  $\text{HCl}$  and  $\text{NaOH}$  are mixed, the **total number** of ions present will be approximately  
(A) twice as great as before mixing.    (B) the same as before mixing.  
(C) half as great as before mixing.    (D)  $10^{-7}$  times as great as before mixing.  
(E)  $10^{-14}$  times as great as before mixing.
37. Oxygen and ozone have the formulas  $\text{O}_2$  and  $\text{O}_3$  respectively. They are  
(A) isomers.    (B) isobars.    (C) allotropes.    (D) isotopes.
38. Which instrument is directly used to determine the relative masses of atoms?  
(A) spectroscope    (B) Geiger counter    (C) mass spectrograph    (D) microbalance  
(E) electron microscope
39. An enclosed mixture has a mass of  $12.69723 \pm 0.00003 \text{ g}$ , and after a chemical change occurs the mixture has a mass of  $12.69724 \pm 0.00003 \text{ g}$ . These results show that  
(A) the law of conservation of matter is not always true.  
(B) the law of conservation of mass is not always true.  
(C) the mass of the enclosed mixture remains constant within the experimental error of the measurement.  
(D) the mass of the enclosed mixture does not change.  
(E) the mass of the enclosed mixture increased.

40. The mechanism of electrical conduction in metals is thought to be  
(A) the same as that in solid electrolytes. (B) the same as that in molten electrolytes.  
(C) dependent on the movement of ions. (D) dependent on the movement of valence electrons.

**Kinetics:**

41. Which is *not* a characteristic of ionic substances?  
(A) Their reactions are generally extremely slow.  
(B) They conduct an electric current when fused.  
(C) Those having a common ion exhibit some similar chemical properties.  
(D) They lower the vapor pressure of water when dissolved in it.  
(E) They raise the boiling point of water when dissolved in it.
42. The addition of a catalyst in a chemical reaction  
(A) increases the concentration of products at equilibrium.  
(B) increases the fraction of reactant molecules with a given kinetic energy.  
(C) provides an alternate path with a different activation energy.  
(D) lowers the enthalpy change in the overall reaction
43. Which procedure will lower the activation energy for a particular reaction?  
(A) subdividing the reactants (B) increasing the reactant concentrations  
(C) increasing the temperature (D) adding a catalyst
44. Which statement most accurately describes the behavior of a catalyst?  
(A) A catalyst increases the  $\Delta G$  of a reaction and hence the forward rate.  
(B) A catalyst reduces the  $\Delta H$  of a reaction and hence the temperature needed to produce products.  
(C) A catalyst reduces the activation energy for a reaction and increases the rate of a reaction.  
(D) A catalyst increases the equilibrium constant and final product concentrations.
45. A catalyst will  
(A) alter the pathway (mechanism) of a chemical reaction. (B) increase  $\Delta H$  for the reaction.  
(C) decrease  $\Delta H$  for the reaction. (D) decrease  $E_a$  for the forward reaction only.

**Laboratory:**

46. A student determines the mass of an object using a triple beam balance which is sensitive to 0.01 g. When the beam balances, the rider on one beam is in the notch marked 60 g, the rider on another beam in the notch marked 7 g, and the rider on the third beam, which is graduated by hundredths of a gram, is at zero. Considering significant figures, what mass should be recorded?  
(A) 67.0 g (B) 76.0 g (C) 67.00 g (D) 76.000 g (E) 67.000 g
47. Which instrument is used to measure the gain or loss of heat?  
(A) manometer (B) hydrometer (C) calorimeter (D) barometer (E) voltmeter
48. What would be the most rapid method of preparing a saturated aqueous solution of  $\text{KNO}_3$  if the solubility is known?  
(A) Add the calculated amount of solute to the proper amount of water at  $20^\circ\text{C}$  and wait until all is dissolved.  
(B) Add to water at  $20^\circ\text{C}$  a slight excess over the calculated amount of solute and water and wait until no more solute dissolves.  
(C) Dissolve less than the calculated amount of solute and let some of the water evaporate at  $20^\circ\text{C}$ .

(D) Add an excess over the calculated amount of solute to hot water and cool to 20 °C, with stirring.  
(E) Neutralize a dilute solution of KOH with dilute HNO<sub>3</sub> and evaporate to the desired volume.

49. Incandescent carbon particles cause a gas flame to be yellow. To obtain a hotter blue flame you should

- (A) open the air holes. (B) close the air holes.  
(C) open the needle valve at the base of the burner to increase the gas supply.  
(D) partly close the supply valve at the gas jet. (E) place a beaker of cold water over the flame to cool the flame.

50. The electrical conductance of a solution of Ba(OH)<sub>2</sub> slowly decreases upon the addition of H<sub>2</sub>SO<sub>4</sub> to a minimum, and then slowly increases. The best **experimental** evidence for this is

- (A) The Ba(OH)<sub>2</sub> solution becomes more dilute since its volume is increased by adding the H<sub>2</sub>SO<sub>4</sub> solution.  
(B) Ions are removed from the solution by the formation of water and insoluble BaSO<sub>4</sub>.  
(C) The inter-ionic attraction effect is increased by adding the H<sub>2</sub>SO<sub>4</sub>.  
(D) An electric lamp placed in a circuit in series with the solution becomes dim as the H<sub>2</sub>SO<sub>4</sub> is added and then becomes bright again.  
(E) An indicator placed in the solution changes color.

**Metals & Non-Metals:**

51. Heating zinc sulfide in air causes the formation of

- (A) Zn and S. (B) Zn and SO<sub>2</sub>. (C) ZnO and S (D) ZnO and SO<sub>2</sub>. (E) Zn and SO<sub>3</sub>.

52. The electrical conductance of a solution of Ba(OH)<sub>2</sub> slowly decreases upon the addition of H<sub>2</sub>SO<sub>4</sub> to a minimum, and then slowly increases. The best **theoretical** explanation of this is

- (A) The Ba(OH)<sub>2</sub> solution becomes more dilute since its volume is increased by adding the H<sub>2</sub>SO<sub>4</sub> solution.  
(B) Ions are removed from the solution by the formation of water and insoluble BaSO<sub>4</sub>.  
(C) The interionic attraction effect is increased by adding the H<sub>2</sub>SO<sub>4</sub>.  
(D) An electric lamp placed in a circuit in series with the solution becomes dim as the H<sub>2</sub>SO<sub>4</sub> is added and then becomes bright again.  
(E) An indicator placed in the solution changes color.

53. Which group of ions can exist together in water solution in moderate concentration?

- (A) Ba<sup>2+</sup>, NO<sub>3</sub><sup>-</sup>, K<sup>+</sup>, CO<sub>3</sub><sup>2-</sup> (B) Ba<sup>2+</sup>, Cl<sup>-</sup>, K<sup>+</sup>, SO<sub>4</sub><sup>2-</sup>  
(C) K<sup>+</sup>, Cl<sup>-</sup>, Na<sup>+</sup>, NO<sub>3</sub><sup>-</sup> (D) Ag<sup>+</sup>, NO<sub>3</sub><sup>-</sup>, K<sup>+</sup>, Cl<sup>-</sup>  
(E) Na<sup>+</sup>, Pb<sup>2+</sup>, Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>

54. Which mixture will **not** yield hydrogen gas?

- (A) sodium and water (B) calcium and water (C) zinc and hydrochloric acid  
(D) zinc and concentrated nitric acid (E) steam and red hot iron

55. When sodium hydroxide solution is added to magnesium sulfate solution, a white precipitate of magnesium hydroxide is obtained. When sodium hydroxide solution is added to an "unknown" solution, a white precipitate is obtained. To conclude that the unknown solution contains magnesium ion, it must be assumed that

- (A) NaOH is more soluble than Mg(OH)<sub>2</sub>. (B) Na<sub>2</sub>SO<sub>4</sub> is soluble in water.

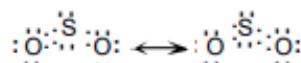
(C)  $\text{Mg}(\text{OH})_2$  is insoluble in water. (D)  $\text{NaOH}$  forms no white precipitate with any other ion except  $\text{Mg}^{2+}$ . (E)  $\text{Zn}^{2+}$ , which forms white  $\text{Zn}(\text{OH})_2$ , is not present in the unknown.

**Molecular Geometry:**

56. An  $sp$  hybridized central atom can be used to describe the bonding in

- (A)  $\text{CH}_4$  (B)  $\text{HCN}$  (C)  $\text{H}_2\text{CO}$  (D)  $\text{OF}_2$

57. Sulfur dioxide can be described by the structures:



This implies that

- (A) the two bonds in  $\text{SO}_2$  are of equal length, and the electronic distribution in the two SO bonds is identical.  
(B) the single bond is longer than the double bond and the electronic distribution in the two SO bonds is different.  
(C) an electron pair in the  $\text{SO}_2$  molecule alternates back and forth between the two sulfur–oxygen electron pairs so that the two different bonds seem to exchange positions.  
(D) the  $\text{SO}_2$  molecule revolves so that the two different bonds seem to exchange positions.

58. Which compound would be expected to have the largest dipole moment?

- (A)  $\text{CO}_2$  (linear) (B)  $\text{SO}_2$  (bent) (C)  $\text{BF}_3$  (trigonal planar) (D)  $\text{CF}_4$  (tetrahedral)

59. Which is the largest bond angle?

- (A) angle O–S–O in  $\text{SO}_4^{2-}$   
(B) angle Cl–C–Cl in  $\text{HCCl}_3$   
(C) angle F–Be–F in  $\text{BeF}_2$   
(D) angle H–O–H in  $\text{H}_2\text{O}$

60. Which molecule is polar?

- (A)  $\text{BF}_3$  (B)  $\text{CO}_2$  (C)  $\text{CF}_4$  (D)  $\text{H}_2\text{S}$

**Oxidation & Reduction:**

61. Consider the reaction  $2\text{Fe}^{3+}(aq) + 2\text{I}^-(aq) \rightarrow 2\text{Fe}^{2+}(aq) + \text{I}_2(aq)$

Which statement is true for the reaction?

- (A)  $\text{Fe}^{3+}$  is oxidized. (B)  $\text{Fe}^{3+}$  increases in oxidation number.  
(C)  $\text{Fe}^{3+}$  is reduced. (D)  $\text{I}^-$  is reduced.

62. In the chemical reaction,  $\text{Zn}_{(s)} + \text{CuSO}_4(aq) \rightarrow \text{ZnSO}_4(aq) + \text{Cu}_{(s)}$ ,

- (A) metallic zinc is the reducing agent. (B) metallic zinc is reduced.  
(C) copper ion is oxidized. (D) sulfate ion is the oxidizing agent.

63. In this reaction, which substance behaves as the oxidizing agent?



- (A) Pb (B)  $\text{PbSO}_4$  (C)  $\text{PbO}_2$  (D)  $\text{H}_2\text{SO}_4$

64. In which group can each substance act as an oxidizing agent?

- (A)  $\text{Cl}_2$ ,  $\text{MnO}_2$ ,  $\text{Cu}^{2+}$  (B)  $\text{Cl}_2$ ,  $\text{MnO}_4^-$ ,  $\text{Cu}^{2+}$  (C)  $\text{Cl}^-$ ,  $\text{MnO}_4^-$ ,  $\text{Cu}^+$  (D)  $\text{Cl}_2$ ,  $\text{Mn}$ ,  $\text{Cu}^{2+}$

65. Which is the strongest oxidizing agent?

Standard Reduction Potentials  $E^\circ$

$\text{Na} \rightleftharpoons \text{Na}^+ + e^-$	2.71 V
$\text{Cd} \rightleftharpoons \text{Cd}^{2+} + 2e^-$	0.40 V
$\text{H}_2 \rightleftharpoons 2\text{H}^+ + 2e^-$	0.00 V
$\text{Ag} \rightleftharpoons \text{Ag}^+ + e^-$	-0.80 V

- (A)  $\text{Na}^+$  (B)  $\text{H}_2$  (C)  $\text{Cd}^0$  (D)  $\text{Ag}^+$

**Periodic Properties:**

66. The molecule  $\text{N}_2$  is isoelectronic with

- (A) formaldehyde,  $\text{CH}_2\text{O}$  (B) cyanide ion,  $\text{CN}^-$  (C) hydrogen,  $\text{H}_2$  (D) water,  $\text{H}_2\text{O}$

67. Which isoelectronic ion is the smallest in size?

- (A)  $\text{Al}^{3+}$  (B)  $\text{Na}^+$  (C)  $\text{F}^-$  (D)  $\text{O}^{2-}$

68. Which of these isoelectronic ions is the smallest?

- (A)  $\text{O}^{2-}$  (B)  $\text{F}^-$  (C)  $\text{Na}^+$  (D)  $\text{Mg}^{2+}$  (E)  $\text{Al}^{3+}$

69. In which pair of particles is the first member larger than the second member?

- (A)  $\text{Li}^+$ ;  $\text{Be}^{2+}$  (B)  $\text{Li}^+$ ;  $\text{Li}$  (C)  $\text{Li}^+$ ;  $\text{Na}^+$  (D)  $\text{Be}$ ;  $\text{Mg}$

70. Which ion has the largest radius?

- (A)  $\text{Cl}^-$  (B)  $\text{F}^-$  (C)  $\text{K}^+$  (D)  $\text{Ca}^{2+}$

**Stoichiometry:**

71. The atomic molar mass of a hypothetical element X is 100 u. It is found that the 50.0 g of X combines with 32.0 g of oxygen. What is the simplest formula for the oxide of X?

Atomic Molar Mass

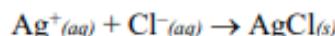
O	16.0 g·mol <sup>-1</sup>
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- (A)  $\text{X}_2\text{O}$  (B)  $\text{XO}_2$  (C)  $\text{X}_2\text{O}_3$  (D)  $\text{XO}_4$

72. An amino acid has a molar mass of 776.9 g·mol<sup>-1</sup> and contains 65.34% iodine by mass. What is the number of iodine atoms per molecule of amino acid?

- (A) one (B) three (C) four (D) five

73. A 6.80 g coin was dissolved in nitric acid and 6.21 g of  $\text{AgCl}$  was precipitated by the addition of excess sodium chloride,



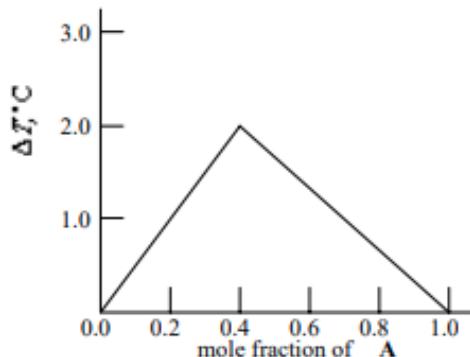
Calculate the percentage silver in the coin.

Atomic Molar Masses

Ag	108. g·mol <sup>-1</sup>
Cl	35.5 g·mol <sup>-1</sup>

- (A) 24.7% (B) 68.7% (C) 75.3% (D) 91.3

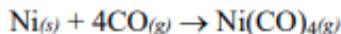
74.



**A** and **B** react exothermically to form a compound. A series of experiments is performed in which varying ratios of **A** to **B** are used, with a constant total number of moles, in each case. The observed temperature rise is plotted above. The simplest formula for the compound is probably

- (A)  $\text{A}_3\text{B}_2$  (B)  $\text{A}_2\text{B}_3$  (C)  $\text{AB}_2$  (D)  $\text{AB}$

75. If a 17.0 g sample of impure nickel metal reacts under standard conditions with 25.0 L of CO to form 6.25 L of  $\text{Ni}(\text{CO})_4$  gas, what is the percentage of Ni in the metal sample?



Molar Masses	
Ni	$58.7 \text{ g}\cdot\text{mol}^{-1}$
$\text{Ni}(\text{CO})_4$	$171. \text{ g}\cdot\text{mol}^{-1}$

- (A) 24.1% (B) 25.0% (C) 96.4% (D) 100%

### Thermochemistry

76. Which molecule has the greatest bond energy?

- (A) H—Br (B) H—F (C) H—At (D) H—Cl (E) H—I

77. For which process is the entropy change per mole the largest at constant temperature?

- (A)  $\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(g)}$  (B)  $\text{H}_2\text{O}_{(s)} \rightarrow \text{H}_2\text{O}_{(g)}$  (C)  $\text{H}_2\text{O}_{(s)} \rightarrow \text{H}_2\text{O}_{(l)}$  (D)  $\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(s)}$

78. Under which conditions does nitrogen have the largest entropy per mole?

- (A)  $\text{N}_{2(s)}$  at 50 K and 1 atm (B)  $\text{N}_{2(l)}$  at 70 K and 1 atm  
(C)  $\text{N}_{2(g)}$  at 80 K and 1 atm (D)  $\text{N}_{2(g)}$  at 80 K and 0.5 atm

79. In which process is entropy decreased?

- (A) dissolving sugar in water (B) expanding a gas (C) evaporating a liquid (D) freezing water

80. Which reaction has the largest positive entropy change per mole of product formed?

- (A)  $\text{S}_{(s)} + 3\text{F}_{2(g)} \rightarrow \text{SF}_{6(g)}$  (B)  $\text{SO}_{2(g)} + \text{Na}_2\text{O}_{(s)} \rightarrow \text{Na}_2\text{SO}_{3(s)}$   
(C)  $\text{Fe}^{3+}_{(aq)} + \text{SCN}^{-}_{(aq)} \rightarrow \text{FeSCN}^{2+}_{(aq)}$  (D)  $\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(g)}$

Answer Key ACS Practice Test 2

**Acids & Bases:**

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

**Atomic Structure:**

- 6. A
- 7. D
- 8. A
- 9. B
- 10. C

**Bonding:**

- 11. B
- 12. D
- 13. A
- 14. E
- 15. C

**Electrochemistry:**

- 16. C
- 17. B
- 18. C
- 19. A
- 20. B

**Equilibrium:**

- 21. D
- 22. D
- 23. C
- 24. A
- 25. D

**Formulas & Equations:**

- 26. D
- 27. B
- 28. D
- 29. A
- 30. A

**Gases:**

- 31. D
- 32. C
- 33. B
- 34. C
- 35. D

**Introductory Concepts:**

- 36. C
- 37. C
- 38. C
- 39. C
- 40. D

**Kinetics:**

- 41. A
- 42. C
- 43. D
- 44. C
- 45. A

**Laboratory:**

- 46. C
- 47. C
- 48. D
- 49. A
- 50. D

**Metals & Nonmetals:**

- 51. D
- 52. B
- 53. C
- 54. D
- 55. D

**Molecular Geometry:**

- 56. B
- 57. A
- 58. B
- 59. C
- 60. D

**Oxidation & Reduction:**

- 61. C
- 62. A
- 63. C
- 64. B
- 65. D

**Periodic Properties:**

- 66. B
- 67. A
- 68. E
- 69. A
- 70. A

**Stoichiometry:**

- 71. D
- 72. C
- 73. B
- 74. B
- 75. C

**Thermochemistry:**

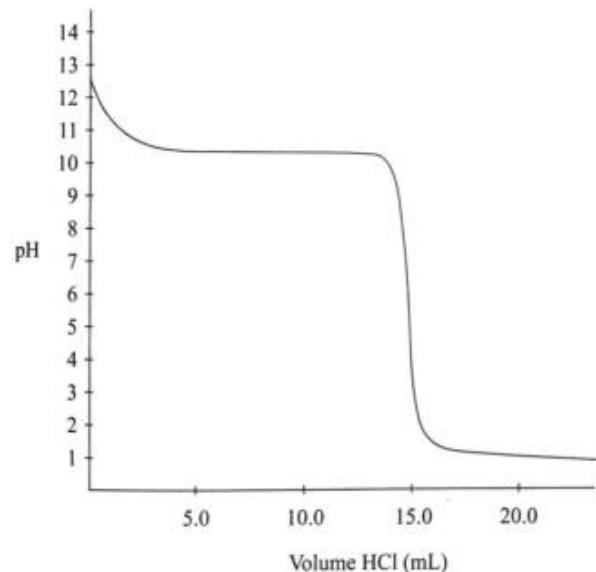
- 76. B
- 77. B
- 78. D
- 79. D
- 80. D

### Practice Test 3: Similar Difficulty to ACS exam

1. In a saturated solution of  $\text{Na}_3\text{PO}_4$ ,  $[\text{Na}^+] = 0.30 \text{ M}$ . What is the molar solubility of  $\text{Na}_3\text{PO}_4$ ?
  - (A)  $0.10 \text{ M}$
  - (B)  $0.30 \text{ M}$
  - (C)  $0.60 \text{ M}$
  - (D)  $0.90 \text{ M}$
  
2. When some LiCl is dissolved in water, the temperature of the water increases. This means that
  - (A) the strength of the intermolecular forces between the water molecules is stronger than the bond energy within the LiCl lattice
  - (B) the attraction of the lithium ions to the negative dipoles of the water molecules is weaker than the attraction of the chloride ions to the positive dipoles of the water molecules
  - (C) breaking the bonds between the lithium and chloride ions is an exothermic process
  - (D) the strength of the ion-dipole attractions that are formed exceeds the lattice energy in LiCl

**Use the following information to answer questions 3-6**

A student titrates some  $1.0 \text{ M HCl}$  into  $20.0 \text{ mL}$  of methylamine ( $\text{CH}_3\text{NH}_2$ ), a weak base which only accepts a single proton. The following titration curve results:



3. What is the concentration of the methylamine?
  - (A)  $0.50 \text{ M}$
  - (B)  $0.75 \text{ M}$
  - (C)  $1.0 \text{ M}$
  - (D)  $1.25 \text{ M}$

4. What is the approximate  $pK_b$  for methylamine?

- (A) 3.5
- (B) 5.5
- (C) 10.5
- (D) 12.5

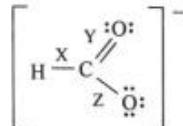
5. The buffer region of this titration is located

- (A) below 3.0 mL
- (B) between 3.0 mL and 14.0 mL
- (C) between 14.0 mL and 16.0 mL
- (D) above 16.0 mL

6. The methylamine is replaced by  $20.0 \text{ mL}$  of sodium hydroxide of an identical concentration. If the sodium hydroxide is titrated with the  $1.0 \text{ M HCl}$ , which of the following options accurately describes the pH levels at various points during the titration when compared to the pH levels at the same point in the HCl/methylamine titration?

	Initial pH	Equivalence pH	Ending pH
(A)	lower	same	higher
(B)	higher	higher	same
(C)	same	higher	same
(D)	higher	lower	lower

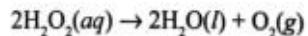
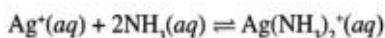
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7. The formate ion,  $\text{HCO}_2^-$ , is best represented by the Lewis diagram below. Each bond is labeled with a different letter.



What is the bond order for each bond?

	X	Y	Z
(A)	1	1	2
(B)	2	2	1
(C)	1	1.5	1.5
(D)	1.33	1.33	1.33

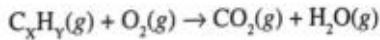
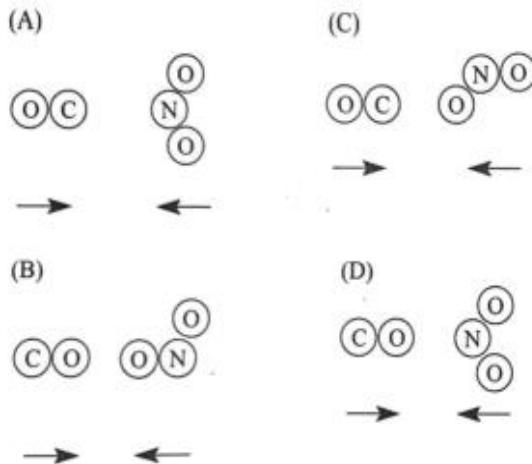
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8. The reaction above is at equilibrium in a closed system. Which of the following will happen immediately when water is added?
- (A) The rate of the reverse reaction will increase.  
(B) Both ions will increase in concentration, while the  $\text{NH}_3$  decreases in concentration.  
(C) The reaction will shift to the right.  
(D) Nothing will happen; adding water does not cause any changes to the equilibrium system.



9. The two products above are created from a reaction involving  $\text{CO}$  and  $\text{NO}_2$ . Which of the following options indicates a viable orientation of both reactant molecules prior to the collision? (Note: the arrows indicate the direction each molecule is moving prior to the collision.)



10. When the above unbalanced reaction occurs at STP, 1.5 L of  $\text{CO}_2$  and 1.0 L of  $\text{H}_2\text{O}$  are created. What is the empirical formula of the hydrocarbon?
- (A)  $\text{CH}_2$   
(B)  $\text{C}_2\text{H}_3$   
(C)  $\text{C}_2\text{H}_5$   
(D)  $\text{C}_3\text{H}_4$

11. For the decomposition of hydrogen peroxide, which element (if any) is being reduced, and which is being oxidized?

	Oxidized	Reduced
(A)	Hydrogen	Oxygen
(B)	Oxygen	None
(C)	None	Hydrogen
(D)	Oxygen	Oxygen

12. Identical amounts of the four gases listed below are present in four separate balloons. At STP, which balloon size experiences the greatest deviation from the volume calculated using the Ideal Gas Law?

- (A)  $\text{H}_2$   
(B)  $\text{O}_2$   
(C)  $\text{N}_2$   
(D)  $\text{F}_2$

13. Which of the following reasons correctly explains one reason that increasing the temperature of a reaction increases its speed?

- (A) All reactant molecules will have more kinetic energy.  
(B) A larger percentage of reactant molecules will exceed the activation energy barrier.  
(C) A higher percentage of molecular collisions will have the correct orientation to cause a reaction.  
(D) The order of each reactant will increase.

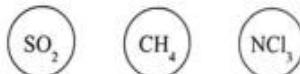
20. The enthalpy change for which of the following reactions would be equal to the enthalpy of formation for ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ )?
- (A)  $\text{CH}_3 + \text{CH}_2 + \text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{OH}$   
 (B)  $2\text{C} + 5\text{H} + \text{O} \rightarrow \text{CH}_3\text{CH}_2\text{OH}$   
 (C)  $4\text{C} + 6\text{H}_2 + \text{O}_2 \rightarrow 2\text{CH}_3\text{CH}_2\text{OH}$   
 (D)  $2\text{C} + 3\text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{CH}_3\text{CH}_2\text{OH}$
24. If a small, pinhole-size leak were to be drilled into each container, the container with which gas would experience the fastest pressure decrease?
- (A)  $\text{SO}_2$   
 (B)  $\text{CH}_4$   
 (C)  $\text{NCl}_3$   
 (D) All three containers would decrease pressure at the same rate.

21. A chemist wants to plate out 1.00 g of solid iron from a solution containing aqueous  $\text{Fe}^{3+}$  ions. Which of the following expressions will equal the amount of time, in seconds, it takes if a current of 5.00 A is applied?

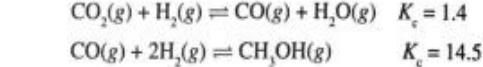
(A)  $\frac{96500}{(2)(55.85)(5.00)}$   
 (B)  $\frac{(2)(96500)}{(55.85)(5.00)}$   
 (C)  $\frac{(55.85)(96500)}{(2)(5.00)}$   
 (D)  $\frac{(2)(55.85)(96500)}{(5.00)}$

Use the following information to answer questions 22-24

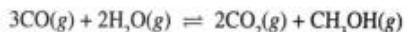
10.0 g each of three different gases are present in three glass containers of identical volume, as shown below. The temperature of all three flasks is held constant at 298 K.



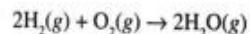
22. The container with which gas would have the greatest pressure?
- (A)  $\text{SO}_2$   
 (B)  $\text{CH}_4$   
 (C)  $\text{NCl}_3$   
 (D) All four containers would have the same pressure.
23. Which of the gases would have the greatest density?
- (A)  $\text{SO}_2$   
 (B)  $\text{CH}_4$   
 (C)  $\text{NCl}_3$   
 (D) All three gases would have the same density.



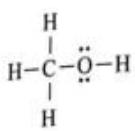
25. Given the above information, what would the equilibrium constant for the below reaction be?



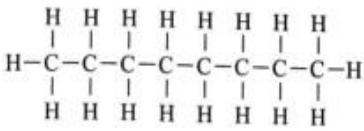
(A)  $(2)(1.4)(14.5)$   
 (B)  $\frac{(1.4)(14.5)}{2}$   
 (C)  $\frac{14.5}{(1.4)^2}$   
 (D)  $14.5 - 1.4^2$



26. When 1.0 mole of  $\text{H}_2$  is combined with 1.0 mol of  $\text{O}_2$  in a sealed flask, the reaction above occurs to completion at a constant temperature. After the reaction, the pressure in the container will have
- (A) increased by 25%  
 (B) increased by 50%  
 (C) decreased by 25%  
 (D) decreased by 50%
27. A strong acid/strong base titration is completed using an indicator which changes color at the exact equivalence point of the titration. The protonated form of the indicator is  $\text{HIn}$ , and the deprotonated form is  $\text{In}^-$ . At the equivalence point of the reaction
- (A)  $[\text{HIn}] = [\text{In}^-]$   
 (B)  $[\text{HIn}] = 1/[\text{In}^-]$   
 (C)  $[\text{HIn}] = 2[\text{In}^-]$   
 (D)  $[\text{HIn}] = [\text{In}^-]^2$



Ethanol



Octane

28. The Lewis diagrams for both ethanol and octane are drawn above. Ethanol's boiling point is 78°C, while octane's is 125°C. This is best explained by the fact that
- (A) octane has hydrogen bonding, while ethanol does not
  - (B) octane has a significantly higher molar mass than ethanol
  - (C) octane's temporary dipoles are stronger than those in ethanol
  - (D) octane is more symmetrical than ethanol
29. Which compound,  $\text{CaCl}_2$  or  $\text{CaO}$ , would you expect to have a high melting point? Why?
- (A)  $\text{CaCl}_2$ , because there are more ions per lattice unit
  - (B)  $\text{CaCl}_2$ , because a chlorine ion is smaller than an oxygen ion
  - (C)  $\text{CaO}$ , because the charge of oxygen ion exceeds that of chlorine ion
  - (D)  $\text{CaO}$ , because the common charges of calcium and oxygen ions are identical in magnitude
30. Even though it is a noble gas, xenon is known to form bonds with other elements. Which element from the options below would xenon most likely be able to bond with?
- (A) Lithium
  - (B) Argon
  - (C) Fluorine
  - (D) Carbon
31. Stock nitric acid,  $\text{HNO}_3$ , has a concentration of 15.8 M. The pH of stock nitric acid would fall into which of the following pH ranges?
- (A) Between -2 and -1
  - (B) Between -1 and 0
  - (C) Between 0 and 1
  - (D) Between 1 and 2

32. During gravimetric analysis experiments, collected precipitates are often rinsed with distilled water prior to being collected. What is the purpose of doing so?

- (A) This ensures the precipitation reaction has gone to completion.
- (B) It washes away any spectator ions stuck to the precipitate.
- (C) The precipitate must be fully hydrated.
- (D) Washing the precipitate ensures it has the correct density.



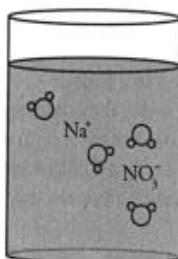
33. The above equilibrium is established in a sealed container. Some neon gas is injected into the container at constant temperature. If the neon does not react with any of the species in the container, what effect will this have on the reaction quotient and the reaction rates for this reaction?

- (A)  $Q$  will increase, causing the forward reaction rate to increase.
- (B)  $Q$  will increase, causing the reverse reaction rate to increase.
- (C)  $Q$  will decrease, causing the forward reaction rate to decrease.
- (D)  $Q$  will remain unchanged and the reaction rates will also remain unchanged.

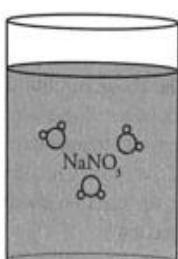
Use the following information to answer questions 34–38.

A 10.0 g sample of  $\text{NaNO}_3$  is dissolved in 200.0 mL of water with stirring, and the temperature of the water changes from  $23.0^\circ\text{C}$  to  $18.0^\circ\text{C}$  during the process. Assume the density and the specific heat of the final solution are identical to those of water.

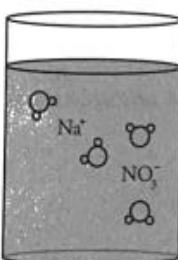
34. Which of the following diagrams correctly shows a particulate representation of the species present in the beaker after the  $\text{NaNO}_3$  has dissolved?



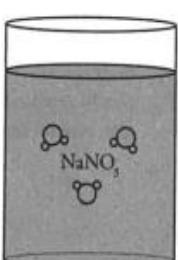
(A)



(C)



(B)



(D)

35. Which of the following statements best describes the enthalpy of solution for  $\text{NaNO}_3$ ?
- It will be greater than zero because energy is absorbed from the water.
  - It will be greater than zero because the magnitude of the ion-dipole attractive forces exceed the lattice energy of  $\text{NaNO}_3$ .
  - It will be less than zero because water is a highly polar solvent.
  - It will be less than zero due to the presence of the polyatomic  $\text{NO}_3^-$  anion.

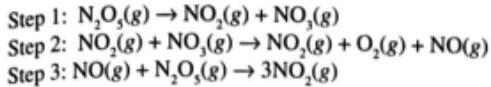
36. During the process, energy is released when
- the ionic bonds within the  $\text{NaNO}_3$  lattice are broken
  - the water molecules are spread apart to make room for the dissolved  $\text{NaNO}_3$
  - new attractive forces form between the dissociated ions and the water dipoles
  - the covalent bonds within the water molecules are broken

37. Which of the following expressions will correctly calculate the heat change experienced by the water?
- $(200.0 \text{ g})(4.18 \text{ J/g}^\circ\text{C})(-5.0^\circ\text{C})$
  - $(210.0 \text{ g})(4.18 \text{ J/g}^\circ\text{C})(-5.0^\circ\text{C})$
  - $(10.0 \text{ g})(4.18 \text{ J/g}^\circ\text{C})(-5.0^\circ\text{C})$
  - $(200.0 \text{ g})(4.18 \text{ J/g}^\circ\text{C})(5.0^\circ\text{C})$

38. After experimentally determining the enthalpy of solution for  $\text{NaNO}_3$  using the gathered data, the magnitude of the experimental value is found to be lower than the accepted value. Which of the following correctly identifies a reason why?
- Some water evaporated while the  $\text{NaNO}_3$  was dissolving.
  - The specific heat of the final solution is actually lower than  $4.18 \text{ J/g}^\circ\text{C}$ .
  - The stirring of the solution added significant energy to the system.
  - Some energy from the dissolution process was lost to the surroundings.

39. Red light has a wavelength of 680 nm, and blue light has a wavelength of 470 nm. Which of the following options correctly identifies the relationships between the frequencies and energy levels of red and blue light?

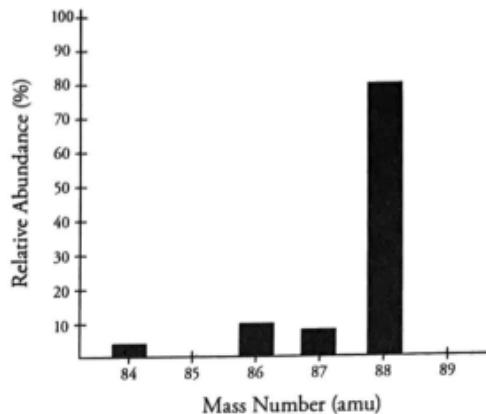
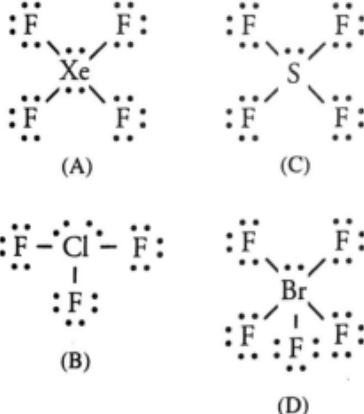
	Frequency	Energy
(A)	Red > Blue	Red > Blue
(B)	Red > Blue	Red < Blue
(C)	Red < Blue	Red > Blue
(D)	Red < Blue	Red < Blue



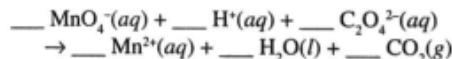
40. The rate law for the above reaction is determined to be  $\text{rate} = k[\text{N}_2\text{O}_5]$ . Which of the following options correctly identifies the overall order of the reaction as well as the molecularity of the rate-determining step?
- First order, unimolecular
  - Second order, bimolecular
  - Third order, bimolecular
  - Fifth order, unimolecular

41. As temperature decreases, the pH of water increases. This means that
- the number of  $\text{H}^+$  and  $\text{OH}^-$  ions are increasing
  - water is more basic at lower temperatures
  - $[\text{H}^+]$  begins to exceed the  $[\text{OH}^-]$
  - the auto-ionization of water is an endothermic process

42. The Lewis diagrams for four different compounds are drawn below. In which molecule would the dipole moment be closest to zero?



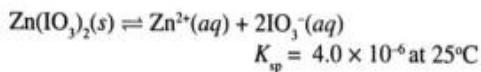
43. The mass spectrum above shows the distribution of various isotopes of strontium. Based on the data, which of the following conclusions can be drawn?
- Strontium most commonly forms ions with a charge of +2.
  - Strontium isotopes with a mass of 86 or 87 are very unstable.
  - The number of protons in a strontium atom nucleus can vary.
  - The most common isotope of strontium has 50 neutrons.



44. When the above oxidation-reduction reaction is completely balanced, what is the coefficient on the  $\text{MnO}_4^-$  ion?
- 1
  - 2
  - 3
  - 4

**Use the following information to answer questions 45-47.**

Zinc iodate dissociates in water via the following equilibrium process



45. What is the approximate molar solubility of zinc iodate at  $25^\circ\text{C}$ ?
- (A)  $1.0 \times 10^{-2} M$   
 (B)  $2.0 \times 10^{-3} M$   
 (C)  $4.0 \times 10^{-6} M$   
 (D)  $1.0 \times 10^{-6} M$

46. Which of the following solutions would zinc iodate be the LEAST soluble in?

- (A)  $1.0 M \text{ BaCl}_2$   
 (B)  $1.0 M \text{ NaIO}_3$   
 (C)  $1.0 M \text{ K}_2\text{CO}_3$   
 (D) Pure water

47. A beaker of saturated zinc iodate is left out overnight. The following morning, some water is found to have evaporated. Assuming the temperature remained constant at  $25^\circ\text{C}$ , which of the following options correctly identifies the changes in the  $[\text{Zn}^{2+}]$  and the mass of the zinc iodate present in the beaker compared to the previous night?

	[ $\text{Zn}^{2+}$ ]	Mass $\text{Zn}(\text{IO}_3)_2$
(A)	Increase	Decrease
(B)	Increase	No Change
(C)	No Change	Increase
(D)	No Change	Decrease

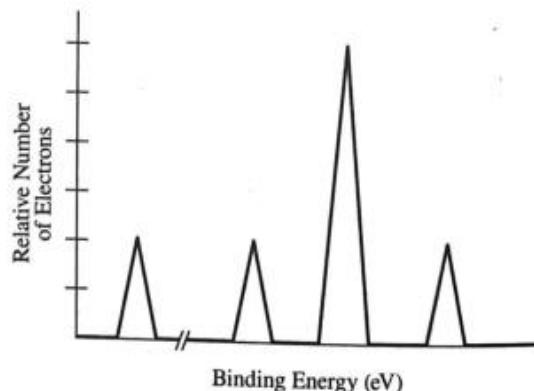
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48. Which of the following reactions would be favored at lower temperatures, but not favored at higher temperatures?

- (A)  $2\text{Fe}_2\text{O}_3(s) + 3\text{C}(s) \rightarrow 4\text{Fe}(s) + 3\text{CO}_2(g)$   
 $\Delta H^\circ = +468 \text{ kJ/mol}_{\text{rxn}}$
- (B)  $\text{S}(g) + \frac{1}{2}\text{O}_2(g) \rightarrow \text{SO}_2(g)$   
 $\Delta H^\circ = -297 \text{ kJ/mol}_{\text{rxn}}$
- (C)  $\text{N}_2\text{H}_4(l) + \text{CH}_2\text{O}(l) \rightarrow \text{CH}_2\text{O}(g) + \text{N}_2(g) + 3\text{H}_2(g)$   
 $\Delta H^\circ = -37 \text{ kJ/mol}_{\text{rxn}}$
- (D)  $2\text{B}(s) + 3\text{H}_2(g) \rightarrow \text{B}_2\text{H}_6(g)$   
 $\Delta H^\circ = +36 \text{ kJ/mol}_{\text{rxn}}$

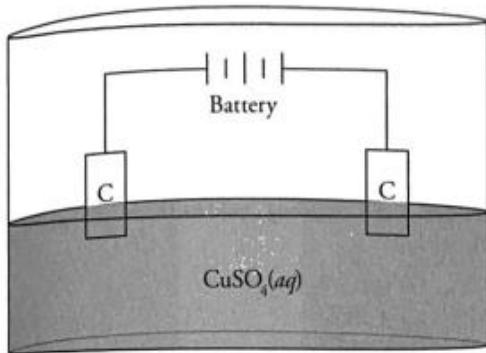
49. Which of the following statements regarding covalent bonds is true?

- (A) Two atoms will form a covalent bond at the distance which minimizes the potential energy between them.
- (B) Covalent bonds always involve the equal sharing of valence electrons between two atoms.
- (C) The breaking of a covalent bond always occurs during a liquid to gas phase change for a covalent substance.
- (D) Covalent bonds typically form between atoms that demonstrate metallic properties.



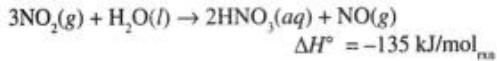
50. The photoelectron spectrum of an element is above. Based on the spectrum, what is the charge on the most common ion of the element?

- (A) -2  
 (B) -1  
 (C) +1  
 (D) +2



51. A beaker is filled with some 1.0 M  $\text{CuSO}_4$ , and two carbon electrodes are placed in the beaker with a battery wired between them, as shown above. As current is run through the system, solid copper plates out onto the carbon cathode. Which of the following changes would increase the amount of solid copper that is plated out of solution?

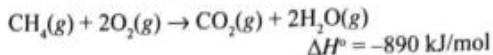
- (A) Replacing the 1.0 M  $\text{CuSO}_4$  solution with 1.0 M  $\text{CuCl}_2$
- (B) Using a 9.0 V battery instead of a 1.5 V battery
- (C) Decreasing the pH of the solution
- (D) Changing out the carbon electrodes with platinum electrodes



52. 1.0 mole of  $\text{NO}_2(g)$  is bubbled through excess water, causing the above reaction to take place. Which of the following statements correctly describes the energy change that will occur during the reaction?

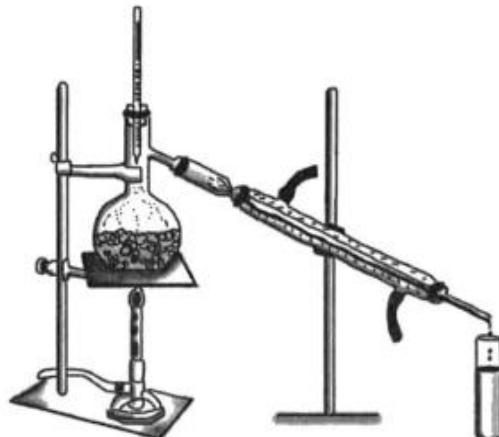
- (A) 135 kJ of energy will be emitted.
- (B) 45 kJ of energy will be emitted.
- (C) 135 kJ of energy will be absorbed.
- (D) 405 kJ of energy will be absorbed.

Bond	Energy (kJ/mol)
C-H	413
O=O	498
O-H	467



53. Determine the approximate bond energy of a C=O bond given the above data.

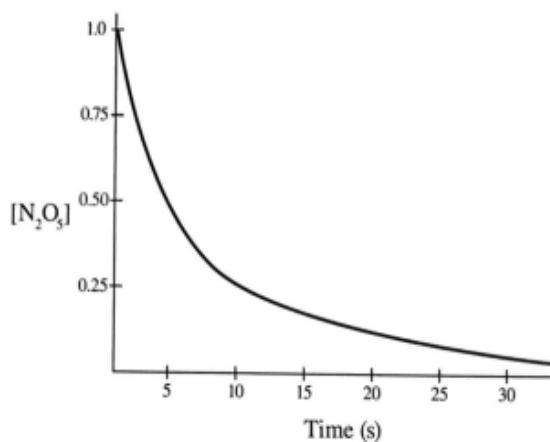
- (A) 400 kJ/mol
- (B) 600 kJ/mol
- (C) 800 kJ/mol
- (D) 1000 kJ/mol



Substance	Vapor Pressure @ 25°C (torr)
$\text{H}_2\text{O}$	23.8
$\text{CH}_3\text{OH}$	99.0
$\text{C}_6\text{H}_{12}$	78.0

54. Three different liquids are mixed together in a flask, and that flask is then hooked up to a distillation apparatus, as shown above. The liquids are initially at 25°C, and the heat is turned up until the mixture starts to boil. Which liquid would be the first to separate out of the mixture?

- (A)  $\text{H}_2\text{O}$
- (B)  $\text{CH}_3\text{OH}$
- (C)  $\text{C}_6\text{H}_{12}$
- (D) Distillation would be an ineffective method of separating the mixture.



55. A sample of some  $\text{N}_2\text{O}_5$  gas is placed in a sealed container and allowed to decompose. The concentration of the  $\text{N}_2\text{O}_5$  is tracked over time, and the results are plotted on the above graph. Which of the following represents the possible units on the rate constant for this reaction?
- (A)  $\text{s}^{-1}$   
 (B)  $\text{sM}^{-1}$   
 (C)  $\text{Ms}^{-1}$   
 (D)  $\text{Ms}^{-2}$



56. The above system is at equilibrium. If it were to be diluted, what would happen to the moles of reactants and the moles product after equilibrium is reestablished?

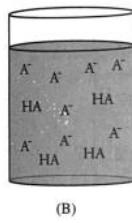
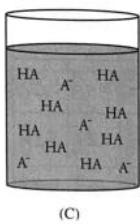
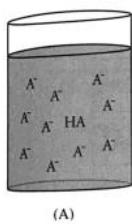
	Mole Reactants	Moles Product
(A)	Increase	Increase
(B)	Increase	Decrease
(C)	Decrease	Decrease
(D)	No Change	No Change

Use the following information to answer questions 57-60.

A beaker contains 100. mL of a 1.0 M solution of benzoic acid,  $\text{C}_6\text{H}_5\text{COOH}$ , which has a  $\text{p}K_a$  value of 4.19. 50. mL of Solution X is added to the beaker, creating a buffer with a pH of 4.19.

57. Which of the following could be the identity of the Solution X?
- (A) 1.0 M NaOH  
 (B) 1.0 M HCl  
 (C) 1.0 M NaCl  
 (D) 1.0 M  $\text{NH}_3$
58. If the buffer solution was then diluted with 150. mL of distilled water, which of the following values would be closest to the pH of the diluted buffer solution?
- (A) 2.08  
 (B) 4.19  
 (C) 5.19  
 (D) 6.27

59. In the diagrams below, benzoic acid is represented by HA, and the benzoate ion,  $C_6H_5COO^-$ , is represented by  $A^-$ . Which of the beakers shows the correct ratio of HA: $A^-$  in a buffer solution that has a pH of 3.19?



60. The benzoic acid solution can be made into an effective buffer. Which of the following statements best explains why a HCl solution of identical concentration NOT be part of a buffer?

- (A) The  $K_a$  value for benzoic acid is greater than the  $K_a$  value for HCl.  
(B) HCl has stronger intermolecular forces than  $C_6H_5COOH$ .  
(C) The  $Cl^-$  ion is a less effective conjugate base than  $C_6H_5COO^-$ .  
(D) HCl has far few protons in it than  $C_6H_5COOH$ .

61. Which of the following ions would have the most unpaired electrons?

- A.  $Na^+$   
B.  $S^{2-}$   
C.  $CO^{2+}$   
D.  $Cr^{2+}$

62. Which of the following solutions would create a buffer system with chlorous acid when added in an equimolar amount?

- A. HCl  
B. NaOH  
C.  $KClO_2$   
D. HOCL

Use the following information to answer questions 63-67



A student wants to determine the enthalpy of solution for potassium nitrite,  $\text{KNO}_2$  (molar mass = 85.1 g/mol). The student takes a sample of  $\text{KNO}_2$  and fully dissolves it into some water that is in a styrofoam cup, gathering the following data. The density and specific heat of the final solution are identical to that of pure water, 1.0 g/mL and 4.2 J/g deg C, respectively.

Mass $\text{KNO}_2$	8.50g
Volume of water	91.50 mL
Initial water temperature	22.5 deg C
Final water temperature	19.5 deg C

63. What is the approximate enthalpy of solution for  $\text{KNO}_2$ ?

- A. -12.6 kJ/mol
- B. -1.26 kJ/mol
- C. 1.26 kJ/mol
- D. 12.6 kJ/mol

64. Which of the following statements is correct regarding the favorability of this process?

- A. The process is favored and driven by enthalpy and entropy
- B. The process is favored and driven by enthalpy only.
- C. The process is favored and driven by entropy only.
- D. The process is not favored.

65. For the reaction to be endothermic, the magnitude of the attractive forces between the dissociated ions and dipoles in the water molecules must be smaller than which of the following?

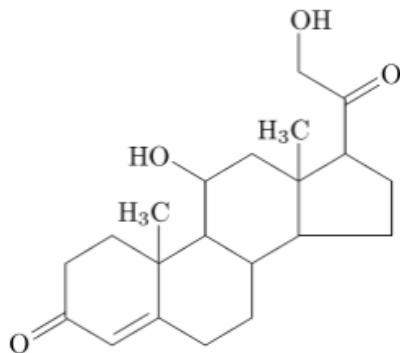
- A. The intermolecular forces between the water molecules
- B. The attractive forces between  $\text{K}^+$  and  $\text{NO}_3^-$  ions in solution
- C. The covalent bond strength within the water molecules
- D. The strength of the ionic bonds in  $\text{KNO}_{3(s)}$  lattice.

66. After the data is gathered, the student notices that not all of the  $\text{KNO}_2$  sample dissolved. How would that affect the calculated enthalpy of solution?

- A. The calculated enthalpy value would be artificially low
- B. The calculated enthalpy value would be artificially high
- C. The calculated enthalpy value would be unchanged
- D. The calculated enthalpy value would have the incorrect sign

67.

The structure of Corticosterone is shown below.



Corticosterone **DOES NOT** contain:

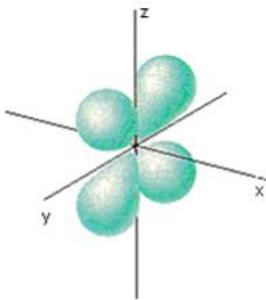
- (A) an alcohol group
- (B) an alkene group
- (C) a ketone group
- (D) an ether group
- (E) a methyl group

68. The quantum numbers that describe Nickel's (Ni) highest energy electron are

- A. n=4 l=1 m<sub>l</sub>=0 m<sub>s</sub>= -1/2
- B. n=3 l=2 m<sub>l</sub>=1 m<sub>s</sub>= -1/2
- C. n=3 l=2 m<sub>l</sub>=0 m<sub>s</sub>= -1/2
- D. n=4 l=1 m<sub>l</sub>=1 m<sub>s</sub>= -1/2

69. Look at the figure below.

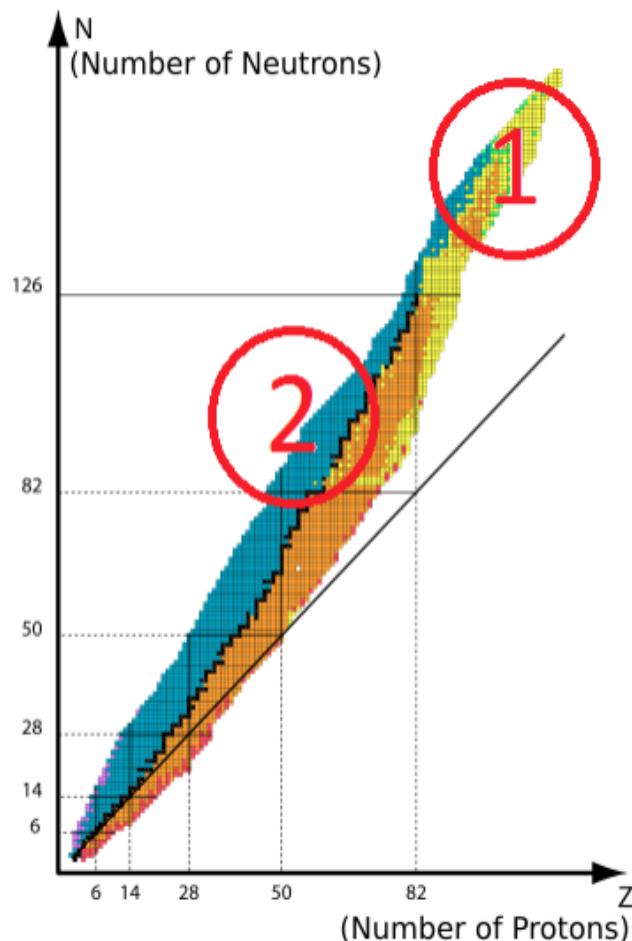
The figure below can be labeled:



- a) a 2p<sub>x</sub> atomic orbital
- b) a 2p<sub>z</sub> atomic orbital
- c) a 5d atomic orbital
- d) a 5s atomic orbital

70)

- Consider the figure below. A nuclide in “Region 1” will likely undergo \_\_\_\_\_ decay and a nuclide in “Region 2” will likely undergo \_\_\_\_\_ decay.



- (A) alpha; beta
- (B) beta; alpha
- (C) alpha; electron capture
- (D) electron capture; alpha

### Practice Test 3 Answer Key

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

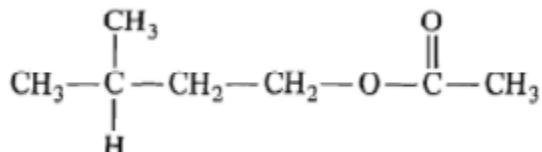
Practice Test 4: Similar Difficulty to ACS exam

Questions 1-3

- (A) F
- (B) S
- (C) Mg
- (D) Ar
- (E) Mn

1. Forms monatomic ions with 2– charge in solutions
  2. Forms a compound having the formula KXO<sub>4</sub>
  3. Forms oxides that are common air pollutants and that yield acidic solution in water
- 
4. For which of the following molecules are resonance structures necessary to describe the bonding satisfactorily?
    - (A) H<sub>2</sub>S
    - (B) SO<sub>2</sub>
    - (C) CO<sub>2</sub>
    - (D) OF<sub>2</sub>
    - (E) PF<sub>3</sub>
- 
5. Which of the following aqueous solutions has the highest boiling point?
    - (A) 0.10 M potassium sulfate, K<sub>2</sub>SO<sub>4</sub>
    - (B) 0.10 M hydrochloric acid, HCl
    - (C) 0.10 M ammonium nitrate, NH<sub>4</sub>NO<sub>3</sub>
    - (D) 0.10 M magnesium sulfate, MgSO<sub>4</sub>
    - (E) 0.20 M sucrose, C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>
- 
6.  $\text{NH}_3(g) + 2 \text{CH}_4(g) + \frac{5}{2} \text{O}_2(g) \rightleftharpoons \text{H}_2\text{NCH}_2\text{COOH}(s) + 3 \text{H}_2\text{O}(l)$   
At constant temperature, ΔH, the change in enthalpy for the reaction above is approximately equal to
    - (A) ΔE – (1½) RT
    - (B) Δ E – (7/2) RT
    - (C) Δ E + RT
    - (D) Δ E + (7/2) RT
    - (E) Δ E – (1½) RT

7.

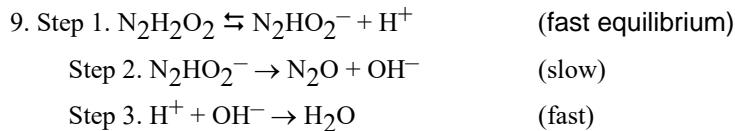


The structure of a molecule of “banana oil” is shown above. This organic compound is an example of

- A) an alcohol
- B) an amine
- C) A carboxylic acid
- D) an ester
- E) a ketone

8. When the actual gas volume is greater than the volume predicted by the ideal gas law, the explanation lies in the fact that the ideal gas law does NOT include a factor for molecular.

- (A) volume
- (B) mass
- (C) velocity
- (D) attractions
- (E) shape



Nitramide,  $\text{N}_2\text{H}_2\text{O}_2$ , decomposes slowly in aqueous solution. This decomposition is believed to occur according to the reaction mechanism above. The rate law for the decomposition of nitramide that is consistent with this mechanism is given by which of the following?

- (A) Rate =  $k [\text{N}_2\text{H}_2\text{O}_2]$   
 (B) Rate =  $k [\text{N}_2\text{H}_2\text{O}_2] [\text{H}^+]$   
 (C) Rate =  $k \frac{[\text{N}_2\text{H}_2\text{O}_2]}{[\text{H}^+]}$   
 (D) Rate =  $k \frac{[\text{N}_2\text{H}_2\text{O}_2]}{[\text{N}_2\text{HO}_2]}$   
 (E) Rate =  $k [\text{N}_2\text{H}_2\text{O}_2] [\text{OH}^-]$

10. A 27.0-gram sample of an unknown hydrocarbon was burned in excess oxygen to form 88.0 grams of carbon dioxide and 27.0 grams of water. What is a possible molecular formula of the hydrocarbon?

- (A)  $\text{CH}_4$  (C)  $\text{C}_4\text{H}_3$  (E)  $\text{C}_4\text{H}_{10}$   
 (B)  $\text{C}_2\text{H}_2$  (D)  $\text{C}_4\text{H}_6$

11. One of the outermost electrons in a strontium atom in the ground state can be described by which of the following sets of four quantum numbers?

- (A) 5, 2, 0,  $\frac{1}{2}$  (D) 5, 0, 1,  $\frac{1}{2}$   
 (B) 5, 1, 1,  $\frac{1}{2}$  (E) 5, 0, 0,  $\frac{1}{2}$   
 (C) 5, 1, 0,  $\frac{1}{2}$

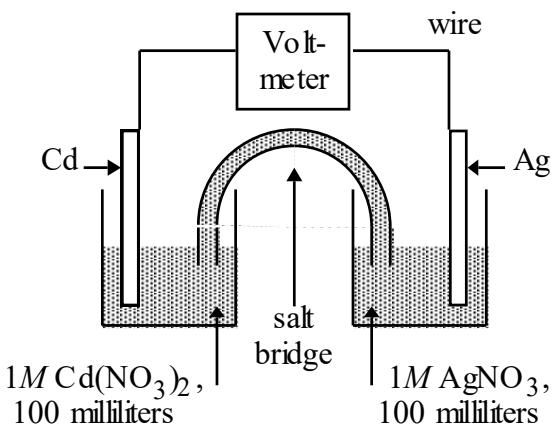
12. How many moles of  $\text{NaF}$  must be dissolved in 1.00 liter of a saturated solution of  $\text{PbF}_2$  at  $25^\circ\text{C}$  to reduce the  $[\text{Pb}^{2+}]$  to  $1 \times 10^{-6}$  molar?

- ( $K_{\text{sp}} \text{ PbF}_2$  at  $25^\circ\text{C} = 4.0 \times 10^{-8}$ )  
 (A) 0.020 mole (C) 0.10 mole (E) 0.40 mole  
 (B) 0.040 mole (D) 0.20 mole

13. If the acid dissociation constant,  $K_a$ , for an acid  $\text{HA}$  is  $8 \times 10^{-4}$  at  $25^\circ\text{C}$ , what percent of the acid is dissociated in a 0.50-molar solution of  $\text{HA}$  at  $25^\circ\text{C}$ ?

- (A) 0.08% (C) 1% (E) 4% (B) 0.2% (D) 2%

Question 14–17



The spontaneous reaction that occurs when the cell above operates is  $2 \text{Ag}^+ + \text{Cd}(s) \rightarrow 2 \text{Ag}(s) + \text{Cd}^{2+}$

- (A) Voltage increases.
- (B) Voltage decreases but remains at zero.
- (C) Voltage becomes zero and remains at zero
- (D) No change in voltage occurs
- (E) Direction of voltage change cannot be predicted without additional information

Which of the above occurs for each of the following circumstances?

14. A 50-milliliter sample of a 2-molar  $\text{Cd}(\text{NO}_3)_2$  solution is added to the left beaker.
15. The silver electrode is made larger.
16. The salt bridge is replaced by a platinum wire.
17. Current is allowed to flow for 5 minutes

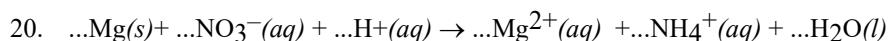
18. Hydrogen Halide	Normal Boiling Point, °C
HF	+19
HCl	-85
HBr	-67
HI	-35

The liquefied hydrogen halides have the normal boiling points given above. The relatively high boiling point of HF can be correctly explained by which of the following?

- (A) HF gas is more ideal.
- (B) HF is the strongest acid.
- (C) HF molecules have a smaller dipole moment.
- (D) HF is much less soluble in water.
- (E) HF molecules tend to form hydrogen bonds.

19. Which of the following represents a pair of isotopes?

		Atomic Number	Mass Number
(A)	I.	6	14
	II.	7	14
(B)	I.	6	7
	II.	14	14
(C)	I.	6	14
	II.	14	28
(D)	I.	7	13
	II.	7	14
(E)	I.	8	10
	II.	16	20

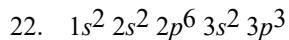


When the skeleton equation above is balanced and all coefficients reduced to their lowest whole-number terms, what is the coefficient for  $\text{H}^+$ ?



21. When a sample of oxygen gas in a closed container of constant volume is heated until its absolute temperature is doubled, which of the following is also doubled?

- (A) The density of the gas  
 (B) The pressure of the gas  
 (C) The average velocity of the gas molecules  
 (D) The number of molecules per  $\text{cm}^3$   
 (E) The potential energy of the molecules



Atoms of an element, X, have the electronic configuration shown above. The compound most likely formed with magnesium, Mg, is

- (A)  $MgX$       (C)  $MgX_2$       (E)  $Mg_3X_2$   
 (B)  $Mg_2X$       (D)  $MgX_3$

23. The density of an unknown gas is 4.20 grams per liter at 3.00 atmospheres pressure and 127°C. What is the molecular weight of this gas?

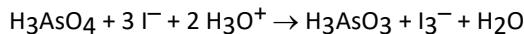
(R = 0.0821 liter-atm/mole-K)



24. The formula for potassium hexacyanoferrate (II) is

- (A)  $K_4[Fe(CN)_6]$       (D)  $K_2[Pt(CN)_6]$   
 (B)  $K_3[Fe(CN)_6]$       (E)  $KCN$   
 (C)  $K_2[Pt(CN)_4]$

### Questions 25–26



The oxidation of iodide ions by arsenic acid in acidic aqueous solution occurs according to the stoichiometry shown above. The experimental rate law of the reaction is:

$$\text{Rate} = k[\text{H}_3\text{AsO}_4^-][\text{I}^-][\text{H}_3\text{O}^+]$$

30. When  $^{214}_{84}\text{Po}$  decays, the emission consists consecutively of an  $\alpha$  particle, then two  $\beta$  particles, and finally another  $\alpha$  particle. The resulting stable nucleus is  
 (A)  $^{206}_{83}\text{Bi}$       (C)  $^{206}_{82}\text{Pb}$       (E)  $^{210}_{81}\text{Tl}$   
 (B)  $^{210}_{83}\text{Bi}$       (D)  $^{208}_{82}\text{Pb}$
31. A 0.1-molar solution of which of the following ions is orange?  
 (A)  $\text{Fe}(\text{H}_2\text{O})_4^{2+}$       (D)  $\text{Zn}(\text{NH}_3)_4^{2+}$   
 (B)  $\text{Cu}(\text{NH}_3)_4^{2+}$       (E)  $\text{Cr}_2\text{O}_7^{2-}$   
 (C)  $\text{Zn}(\text{OH})_4$
32. The net ionic equation for the reaction between silver carbonate and hydrochloric acid is  
 (A)  $\text{Ag}_2\text{CO}_3(s) + 2 \text{H}^+ + 2 \text{Cl}^- \rightarrow 2 \text{AgCl}(s) + \text{H}_2\text{O} + \text{CO}_2(g)$   
 (B)  $2 \text{Ag}^+ + \text{CO}_3^{2-} + 2 \text{H}^+ + 2 \text{Cl}^- \rightarrow 2 \text{AgCl}(s) + \text{H}_2\text{O} + \text{CO}_2(g)$   
 (C)  $\text{CO}_3^{2-} + 2 \text{H}^+ \rightarrow \text{H}_2\text{O} + \text{CO}_2(g)$   
 (D)  $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}(s)$   
 (E)  $\text{Ag}_2\text{CO}_3(s) + 2 \text{H}^+ \rightarrow 2 \text{Ag}^+ + \text{H}_2\text{CO}_3$
33. The pH of 0.1-molar ammonia is approximately  
 (A) 1      (B) 4      (C) 7      (D) 11      (E) 14
34.  $\dots\text{CrO}_2^- + \dots\text{OH}^- \rightarrow \dots\text{CrO}_4^{2-} + \dots\text{H}_2\text{O} + \dots\text{e}^-$   
 When the equation for the half-reaction above is balanced, what is the ratio of the coefficients  $\text{OH}^-/\text{CrO}_2^-$ ?  
 (A) 1:1      (B) 2:1      (C) 3:1      (D) 4:1      (E) 5:1
35. The addition of an oxidizing agent such as chlorine water to a clear solution of an unknown compound results in the appearance of a brown color. When this solution is shaken with the organic solvent, methylene dichloride, the organic solvent layer turns purple. The unknown compound probably contains  
 (A)  $\text{K}^+$       (C)  $\text{NO}_3^-$       (E)  $\text{Co}^{2+}$   
 (B)  $\text{Br}^-$       (D)  $\text{I}^-$
36.  $\text{CuO}(s) + \text{H}_2(g) \rightleftharpoons \text{Cu}(s) + \text{H}_2\text{O}(g)$   $\Delta H = -2.0 \text{ kilojoules}$   
 When the substances in the equation above are at equilibrium at pressure P and temperature T, the equilibrium can be shifted to favor the products by  
 (A) increasing the pressure by means of a moving piston at constant T  
 (B) increasing the pressure by adding an inert gas such as nitrogen  
 (C) decreasing the temperature  
 (D) allowing some gases to escape at constant P and T  
 (E) adding a catalyst

37. The molality of the glucose in a 1.0-molar glucose solution can be obtained by using which of the following?
- (A) Volume of the solution  
(B) Temperature of the solution  
(C) Solubility of glucose in water  
(D) Degree of dissociation of glucose  
(E) Density of the solution
38. The radioactive decay of  $^{14}_6\text{C}$  to  $^{14}_7\text{N}$  occurs by the process of
- (A) beta particle emission      (D) electron capture  
(B) alpha particle emission      (E) neutron capture  
(C) positron emission
39. Equal masses of three different ideal gases, X, Y, and Z, are mixed in a sealed rigid container. If the temperature of the system remains constant, which of the following statements about the partial pressure of gas X is correct?
- (A) It is equal to  $1/3$  the total pressure  
(B) It depends on the intermolecular forces of attraction between molecules of X, Y, and Z.  
(C) It depends on the relative molecular masses of X, Y, and Z.  
(D) It depends on the average distance traveled between molecular collisions.  
(E) It can be calculated with knowledge only of the volume of the container.
40. The geometry of the  $\text{SO}_3$  molecule is best described as
- (A) trigonal planar      (D) bent  
(B) trigonal pyramidal      (E) tetrahedral  
(C) square pyramidal
41. Which of the following molecules has the shortest bond length?
- (A)  $\text{N}_2$       (C)  $\text{Cl}_2$       (E)  $\text{I}_2$   
(B)  $\text{O}_2$       (D)  $\text{Br}_2$
42. Metallic copper is heated strongly with concentrated sulfuric acid. The products of this reaction are
- (A)  $\text{CuSO}_4(s)$  and  $\text{H}_2(g)$  only  
(B)  $\text{Cu}^{2+}$ ,  $\text{SO}_2(g)$ , and  $\text{H}_2\text{O}$   
(C)  $\text{Cu}^{2+}$ ,  $\text{H}_2(g)$ , and  $\text{H}_2\text{O}$   
(D)  $\text{CuSO}_4(s)$ ,  $\text{H}_2(g)$ , and  $\text{SO}_2(g)$   
(E)  $\text{Cu}^{2+}$ ,  $\text{SO}_3(g)$ , and  $\text{H}_2\text{O}$
43. The elements in which of the following have most nearly the same atomic radius?
- (A) Be, B, C, N      (D) C, P, Se, I  
(B) Ne, Ar, Kr, Xe      (E) Cr, Mn, Fe, Co  
(C) Mg, Ca, Sr, Ba
44. What number of moles of  $\text{O}_2$  is needed to produce 14.2 grams of  $\text{P}_4\text{O}_{10}$  from P? (Molecular weight  $\text{P}_4\text{O}_{10} = 284$ )
- (A) 0.0500 mole      (D) 0.250 mole  
(B) 0.0625 mole      (E) 0.500 mole  
(C) 0.125 mole

45. The alkenes are compounds of carbon and hydrogen with the general formula  $C_nH_{2n}$ . If 0.561 gram of any alkene is burned in excess oxygen, what number of moles of  $H_2O$  is formed?  
(A) 0.0400 mole      (D) 0.400 mole  
(B) 0.0600 mole      (E) 0.800 mole  
(C) 0.0800 mole

46. If 0.060 faraday is passed through an electrolytic cell containing a solution of  $In^{3+}$  ions, the maximum number of moles of In that could be deposited at the cathode is  
(A) 0.010 mole      (D) 0.060 mole  
(B) 0.020 mole      (E) 0.18 mole  
(C) 0.030 mole

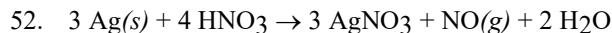
47.  $CH_4(g) + 2 O_2(g) \rightarrow CO_2(g) + 2 H_2O(l)$        $\Delta H^\circ = -889.1 \text{ kJ}$   
 $\Delta H_f^\circ H_2O(l) = -285.8 \text{ kJ/mol}$   
 $\Delta H_f^\circ CO_2(g) = -393.3 \text{ kJ/mol}$   
What is the standard heat of formation of methane,  $\Delta H_f^\circ CH_4(g)$ , as calculated from the data above?  
(A) -210.0 kJ/mole      (D) 75.8 kJ/mole  
(B) -107.5 kJ/mole      (E) 210.0 kJ/mole  
(C) -75.8 kJ/mole

48. Which of the following ions is the strongest Lewis acid?  
(A)  $Na^+$       (C)  $CH_3COO^-$       (E)  $Al^{3+}$   
(B)  $Cl^-$       (D)  $Mg^{2+}$

49. Each of the following can act as both a Brönsted acid and a Brönsted base EXCEPT  
(A)  $HCO_3^-$       (C)  $NH_4^+$       (E)  $HS^-$   
(B)  $H_2PO_4^-$       (D)  $H_2O$

50. Two flexible containers for gases are at the same temperature and pressure. One holds 0.50 gram of hydrogen and the other holds 8.0 grams of oxygen. Which of the following statements regarding these gas samples is FALSE?  
(A) The volume of the hydrogen container is the same as the volume of the oxygen container.  
(B) The number of molecules in the hydrogen container is the same as the number of molecules in the oxygen container.  
(C) The density of the hydrogen sample is less than that of the oxygen sample.  
(D) The average kinetic energy of the hydrogen molecules is the same as the average kinetic energy of the oxygen molecules.  
(E) The average speed of the hydrogen molecules is the same as the average speed of the oxygen molecules.

51. Pi ( $\pi$ ) bonding occurs in each of the following species EXCEPT  
(A)  $CO_2$       (C)  $CN^-$       (E)  $CH_4$   
(B)  $C_2H_4$       (D)  $C_6H_6$



The reaction of silver metal and dilute nitric acid proceeds according to the equation above. If 0.10 mole of powdered silver is added to 10. milliliters of 6.0–molar nitric acid, the number of moles of NO gas that can be formed is

- (A) 0.015 mole      (C) 0.030 mole      (E) 0.090 mole  
(B) 0.020 mole      (D) 0.045 mole

53. Which, if any, of the following species is in the greatest concentration in a 0.100–molar solution of  $\text{H}_2\text{SO}_4$  in water?

- (A)  $\text{H}_2\text{SO}_4$  molecules      (C)  $\text{HSO}_4^-$  ions  
(B)  $\text{H}_3\text{O}^+$  ions      (D)  $\text{SO}_4^{2-}$  ions  
(E) All species are in equilibrium and therefore have the same concentrations.

54. Which of the following statements is always true about the phase diagram of any one–component system?

- (A) The slope of the curve representing equilibrium between the vapor and liquid phases is positive.  
(B) The slope of the curve representing equilibrium between the liquid and solid phases is negative.  
(C) The slope of the curve representing equilibrium between the liquid and solid phases is positive.  
(D) The temperature at the triple point is greater than the normal freezing point.  
(E) The pressure at the triple point is greater than 1 atmosphere.

55. At 20.°C, the vapor pressure of toluene is 22 millimeters of mercury and that of benzene is 75 millimeters of mercury. An ideal solution, equimolar in toluene and benzene, is prepared. At 20.°C, what is the mole fraction of benzene in the vapor in equilibrium with this solution?

- (A) 0.23      (C) 0.50      (E) 0.83  
(B) 0.29      (D) 0.77

56. A cube of ice is added to some hot water in a rigid, insulated container, which is then sealed. There is no heat exchange with the surroundings. What has happened to the total energy and the total entropy when the system reaches equilibrium?

- | <u>Energy</u>        | <u>Entropy</u>   |
|----------------------|------------------|
| (A) Remains constant | Remains constant |
| (B) Remains constant | Decreases        |
| (C) Remains constant | Increases        |
| (D) Decreases        | Increases        |
| (E) Increases        | Decreases        |

57. For the reaction  $\text{A}(g) \rightleftharpoons \text{B}(g) + \text{C}(g)$ , the equilibrium constant,  $K_p$ , is  $2 \times 10^{-4}$  at 25°C. A mixture of the three gases at 25°C is placed in a reaction flask and the initial pressures are  $P_A = 21$  atmosphere,  $P_B = 0.5$  atmosphere, and  $P_C = 1$  atmosphere. At the instant of mixing, which of the following is true for the reaction as written?

- (A)  $\Delta G < 0$       (C)  $\Delta S = 0$       (E)  $\Delta G^\circ < 0$   
(B)  $\Delta G > 0$       (D)  $\Delta G^\circ = 0$

58. Which of the following represents the ground state electron configuration for the  $\text{Mn}^{3+}$  ion? (Atomic number Mn = 25)

- (A)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$   
(B)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$   
(C)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$   
(D)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$   
(E)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^1$

59. When 70. milliliter of 3.0-molar  $\text{Na}_2\text{CO}_3$  is added to 30. milliliters of 1.0-molar  $\text{NaHCO}_3$  the resulting concentration of  $\text{Na}^+$  is  
 (A) 2.0 M                    (C) 4.0 M                    (E) 7.0 M  
 (B) 2.4 M                    (D) 4.5 M
60. Which of the following has a zero dipole moment?  
 (A) HCN                    (C)  $\text{SO}_2$                     (E)  $\text{PF}_5$   
 (B)  $\text{NH}_3$                     (D)  $\text{NO}_2$
61. When a solution of potassium dichromate is added to an acidified solution of iron(II) sulfate, the products of the reaction are  
 (A)  $\text{FeCr}_2\text{O}_7(s)$  and  $\text{H}_2\text{O}$   
 (B)  $\text{FeCrO}_4(s)$  and  $\text{H}_2\text{O}$   
 (C)  $\text{Fe}^{3+}$ ,  $\text{CrO}_4^{2-}$ , and  $\text{H}_2\text{O}$   
 (D)  $\text{Fe}^{3+}$ ,  $\text{Cr}^{3+}$ , and  $\text{H}_2\text{O}$   
 (E)  $\text{Fe}_2(\text{SO}_4)_3(s)$ ,  $\text{Cr}^{3+}$  and  $\text{H}_2\text{O}$
62. A student pipetted five 25.00-milliliter samples of hydrochloric acid and transferred each sample to an Erlenmeyer flask, diluted it with distilled water, and added a few drops of phenolphthalein to each. Each sample was then titrated with a sodium hydroxide solution to the appearance of the first permanent faint pink color. The following results were obtained.

Volumes of NaOH Solution

First Sample .....	35.22 mL
Second Sample.....	36.14 mL
Third Sample.....	36.13 mL
Fourth Sample.....	36.15 mL
Fifth Sample.....	36.12 mL

- Which of the following is the most probable explanation for the variation in the student's results?
- (A) The burette was not rinsed with NaOH solution  
 (B) The student misread a 5 for a 6 on the burette when the first sample was titrated.  
 (C) A different amount of water was added to the first sample.  
 (D) The pipette was not rinsed with the HCl solution.  
 (E) The student added too little indicator to the first sample.
63. Acid      Acid Dissociation Constant,  $K_a$
- |                           |                     |
|---------------------------|---------------------|
| $\text{H}_3\text{PO}_4$   | $7 \times 10^{-3}$  |
| $\text{H}_2\text{PO}_4^-$ | $8 \times 10^{-8}$  |
| $\text{HPO}_4^{2-}$       | $5 \times 10^{-13}$ |
- On the basis of the information above, a buffer with a pH = 9 can best be made by using  
 (A) pure  $\text{NaH}_2\text{PO}_4$                     (D)  $\text{H}_2\text{PO}_4^- + \text{HPO}_4^{2-}$   
 (B)  $\text{H}_3\text{PO}_4 + \text{H}_2\text{PO}_4^-$                     (E)  $\text{HPO}_4^{2-} + \text{PO}_4^{3-}$   
 (C)  $\text{H}_2\text{PO}_4^- + \text{PO}_4^{2-}$

64. The net ionic equation for the reaction that occurs during the titration of nitrous acid with sodium hydroxide is
- $\text{HNO}_2 + \text{Na}^+ + \text{OH}^- \rightarrow \text{NaNO}_2 + \text{H}_2\text{O}$
  - $\text{HNO}_2 + \text{NaOH} \rightarrow \text{Na}^+ + \text{NO}_2^- + \text{H}_2\text{O}$
  - $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$
  - $\text{HNO}_2 + \text{H}_2\text{O} \rightarrow \text{NO}_2^- + \text{H}_3\text{O}^+$
  - $\text{HNO}_2 + \text{OH}^- \rightarrow \text{NO}_2^- + \text{H}_2\text{O}$
65. Which of the following species CANNOT function as an oxidizing agent?
- $\text{Cr}_2\text{O}_7^{2-}$
  - $\text{NO}_3^-$
  - $\text{I}^-$
  - $\text{MnO}_4^-$
  - $\text{S}$
66. Ca, V, Co, Zn, As  
Gaseous atoms of which of the elements above are paramagnetic?
- Ca and As only
  - Zn and As only
  - Ca, V, and Co only
  - V, Co, and As only
  - V, Co, and Zn only
67.  $\text{HgO}(s) + \text{H}_2\text{O} \rightleftharpoons \text{HgI}_4^{2-} + 2 \text{OH}^-$   
Consider the equilibrium above. Which of the following changes will increase the concentration of  $\text{HgI}_4^{2-}$ ?
- Increasing the concentration of  $\text{OH}^-$
  - Adding 6 M  $\text{HNO}_3$
  - Increasing the mass of  $\text{HgO}$  present
  - Increasing the temperature
  - Adding a catalyst
68. A 20.0-milliliter sample of 0.200-molar  $\text{K}_2\text{CO}_3$  solution is added to 30.0 milliliters of 0.400-molar  $\text{Ba}(\text{NO}_3)_2$  solution. Barium carbonate precipitates. The concentration of barium ion,  $\text{Ba}^{2+}$ , in solution after reaction is
- 0.150 M
  - 0.160 M
  - 0.200 M
  - 0.240 M
  - 0.267 M
69. What is the mole fraction of ethanol,  $\text{C}_2\text{H}_5\text{OH}$ , in an aqueous solution in which the ethanol concentration is 4.6 molal?
- 0.0046
  - 0.076
  - 0.083
  - 0.20
  - 0.72
70.  
Which of the following best helps to account for the fact that the  $\text{F}^-$  ion is smaller than the  $\text{O}^{2-}$  ion?
- $\text{F}^-$  has a larger nuclear mass than  $\text{O}^{2-}$  has.
  - $\text{F}^-$  has a larger nuclear charge than  $\text{O}^{2-}$  has.
  - $\text{F}^-$  has more electrons than  $\text{O}^{2-}$  has.
  - $\text{F}^-$  is more electronegative than  $\text{O}^{2-}$  is.
  - $\text{F}^-$  is more polarizable than  $\text{O}^{2-}$  is.

#### **Practice Test 4 Answer Key**

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