

Advanced Placement Chemistry

Practice Exam I

Three hours are allotted for this examination. One hour and 30 minutes are allotted for Section I, which consists of multiple-choice questions. For Section II, Part A, 40 minutes are allotted; for Section II, Part B, 50 minutes are allotted.

NO CALCULATORS MAY BE USED IN THIS SECTION OF THE EXAMINATION.

SECTION I

Time—1 hour and 30 minutes

Number of questions—75

Percent of total grade—45

Note: For all questions, assume that the temperature is 298 K, the pressure is 1.00 atmosphere and solutions are aqueous unless otherwise noted.

Throughout the test the following symbols have the definitions specified unless otherwise noted.

T	=	temperature	M	=	molar
P	=	pressure	m	=	molal
V	=	volume	L, mL	=	liter(s), milliliter(s)
S	=	entropy	g	=	gram(s)
H	=	enthalpy	nm	=	nanometer(s)
G	=	free energy	atm	=	atmosphere(s)
R	=	molar gas constant	J, kJ	=	joule(s), kilojoule(s)
n	=	number of moles	V	=	volt(s)
			mol	=	mole(s)

Part A

Directions: Each set of lettered choices below refers to the numbered statements immediately following it. Select the one lettered choice that best answers each question or best fits each statement and then fill in the corresponding oval on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1 - 4 refer to aqueous solutions containing 1:1 mole ratios of the following pairs of substances. Assume all concentrations are 1 M.

- (A) sodium hydroxide and ammonia
- (B) sodium hydroxide and hydrochloric acid
- (C) hydrobromic acid and potassium bromide
- (D) acetic acid and sodium acetate
- (E) methylamine and methylammonium chloride

1. A buffer with a pH less than 7
2. A buffer with a pH greater than 7
3. The solution with a pH of 7
4. The solution with the highest pH

Questions 5 – 8 refer to the following

- (A) hydrogen bonding
- (B) Valence Bond theory
- (C) dispersion forces
- (D) VSEPR theory
- (E) Coulomb's Law

5. Is used to explain why MgCl_2 has a much higher melting point than NaCl .
6. Is used to explain why the boiling point of H_2O is greater than the boiling point of H_2S .
7. Is used to explain the fact that the four bonds in methane are equivalent.
8. Is used to explain the fact that the hydrogen-oxygen-hydrogen bond in water is approximately 105° .

Use these answers for questions 9 - 12

- (A) $1s^2 2s^2 2p^6 3s^2 3p^5$
- (B) $1s^2 2s^2 2p^6 3s^2 3p^6$
- (C) $1s^2 2s^2 2p^6 2d^{10} 3s^2 3p^6$
- (D) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
- (E) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

9. The ground-state configuration of the +1 ion of copper.
10. The ground-state configuration of the fluoride ion.
11. The ground-state configuration of a common ion of an alkali metal.
12. The ground-state configuration of a common halogen.

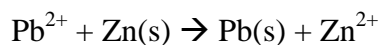
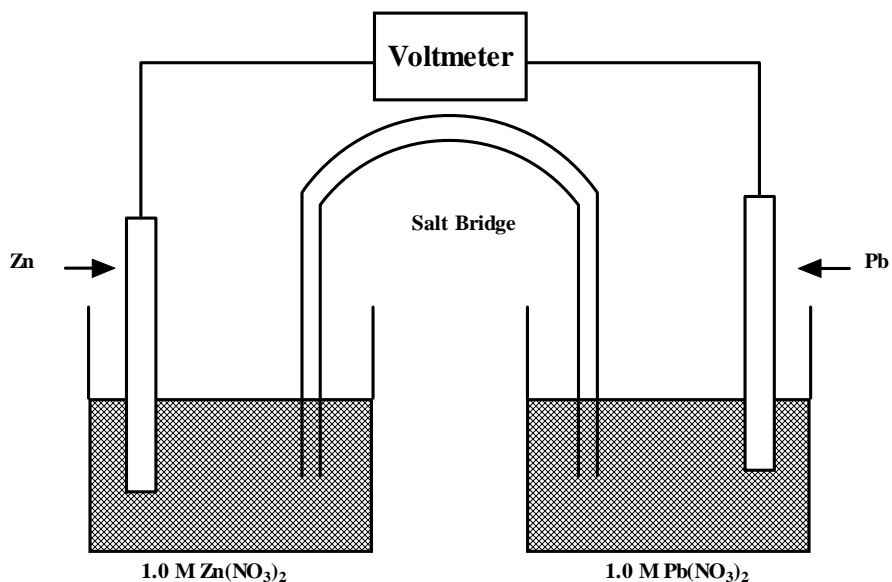
Use these answers for questions 13 -16

- (A) Nitric acid
- (B) Sulfur dioxide
- (C) Hydrochloric acid
- (D) Zinc
- (E) Potassium permanganate

13. A strong oxidizing agent that changes color upon reduction.
14. Is known as the oxidizing acid.
15. Is used to galvanize building materials.
16. Is known to cause acid rain.

Questions 17 – 20 refer to the diagram below:

The spontaneous reaction that occurs when the cell above operates is:



- (A) Voltage increases.
- (B) Voltage decreases.
- (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?

- 17. A 50-milliliter sample of a 2-molar NaCl solution is added to the right beaker.
- 18. The salt bridge is removed.
- 19. 100 mL of water is added to the beaker on the left.
- 20. Current is allowed to flow for 10 minutes.

Part B

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding oval on the answer sheet.

21. A yellow precipitate forms when 0.5 M KI(aq) is added to a 0.5 M solution of which of the following ions?

- A) Pb^{2+} (aq)
- B) Cu^{2+} (aq)
- C) $\text{C}_2\text{O}_4^{2-}$ (aq)
- D) SO_4^{2-} (aq)
- E) Cl^- (aq)

22. $\text{MgO(s)} + \text{H}_2\text{(g)} \rightleftharpoons \text{Mg(s)} + \text{H}_2\text{O(g)}$
 $\Delta H = - 14.0$ 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 in the reaction vessel while keeping the temperature constant.
- (B) increasing the pressure by adding an inert gas such as argon
- (C) decreasing the temperature
- (D) allowing some hydrogen gas to escape at constant P and T
- (E) adding a catalyst

23. Each of the following can act as both a Brönsted acid and a Brönsted base EXCEPT

- (A) HSO_3^-
- (B) HPO_4^{2-}
- (C) NH_4^+
- (D) H_2O
- (E) HCO_3^-

24. A student pipetted five 25.00-milliliter samples of acetic acid and transferred each sample to a beaker, 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.

Solution	Volumes of NaOH
First Sample.....	15.33 mL
Second Sample.....	16.35 mL
Third Sample.....	16.37 mL
Fourth Sample.....	16.40 mL
Fifth Sample.....	16.38 mL

Which of the following is the most probable explanation for the variation in the student's results?

- (A) More water was added to the first sample.
- (B) More phenolphthalein was added to the first sample.
- (C) The first sample was titrated beyond the end point.
- (D) The pipette was not rinsed with the acetic acid solution.
- (E) The buret was not rinsed with the NaOH solution.

25. Which of the following reactions has the largest positive value of ΔS ?

- (A) $2\text{H}_2\text{S(g)} + \text{SO}_2\text{(g)} \rightarrow 3 \text{S (s)} + 2 \text{H}_2\text{O(g)}$
- (B) $2 \text{SO}_3\text{(g)} \rightarrow 2 \text{SO}_2\text{(g)} + \text{O}_2\text{(g)}$
- (C) $\text{Mg(s)} + \text{Cl}_2\text{(g)} \rightarrow \text{MgCl}_2\text{(s)}$
- (D) $\text{Fe}_2\text{O}_3\text{(s)} + 3\text{H}_2\text{(g)} \rightarrow 2 \text{Fe(s)} + 3 \text{H}_2\text{O(g)}$
- (E) $\text{H}_2\text{(g)} + \frac{1}{2} \text{O}_2\text{(g)} \rightarrow \text{H}_2\text{O(l)}$

26. In the periodic table, as the atomic number increases from 3 to 10, what happens to the atomic radius?

- (A) It decreases only
- (B) It decreases, then increases.
- (C) It remains constant.
- (D) It increases only.
- (E) It increases, and then decreases.

27. Two flexible containers for gases are at the same temperature and pressure. One holds 14 grams of nitrogen and the other holds 22 grams of carbon dioxide. Which of the following statements regarding these gas samples is TRUE?

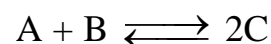
- (A) The volume of the carbon dioxide container is the same as the volume of the nitrogen container.
- (B) The number of molecules in the carbon dioxide container is greater than the number of molecules in the nitrogen container.
- (C) The density of the carbon dioxide sample is the same as that of the nitrogen sample.
- (D) The average kinetic energy of the carbon dioxide molecules is greater than the average kinetic energy of the nitrogen molecules.
- (E) The average speed of the carbon dioxide molecules is greater than the average speed of the nitrogen molecules.

28. The XeF_4 molecule has an octahedral structure. Therefore, the hybridization of Xe orbitals should be

- (A) sp^2
- (B) sp^3
- (C) dsp^2
- (D) dsp^3
- (E) d^2sp^3

Experiment	Initial [A] (mol L ⁻¹)	Initial [B] (mol L ⁻¹)	Initial Rate of Formation of product [C] (mol L ⁻¹ s ⁻¹)
1	0.10	0.10	2.5×10^{-4}
2	0.20	0.10	5.0×10^{-4}
3	0.20	0.50	1.25×10^{-2}

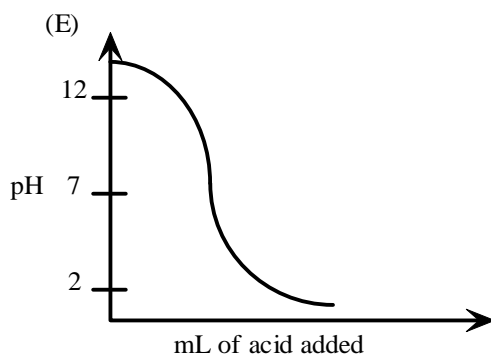
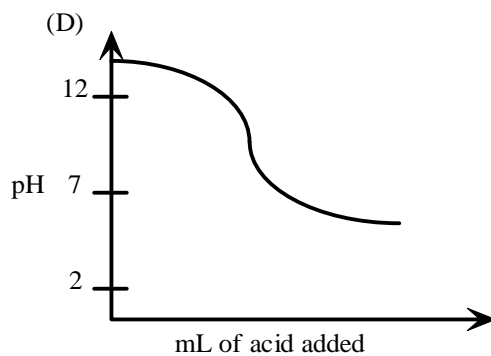
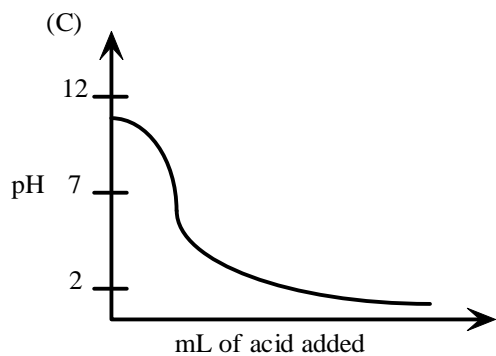
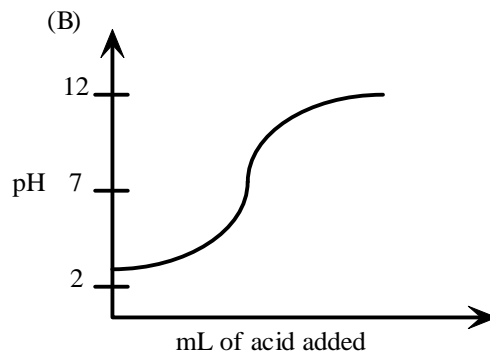
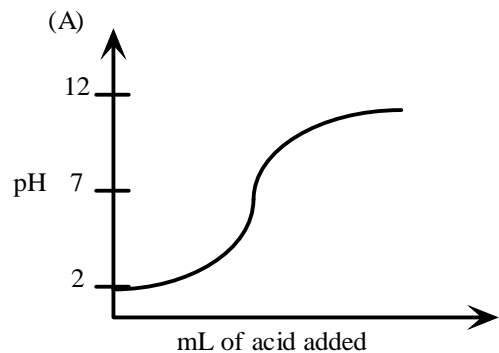
29. The initial-rate data in the table above were obtained for the reaction represented below. What is the experimental rate law for the

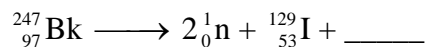


reaction?

- (A) rate = $k[A][B]$
- (B) rate = $k[A][B]^2$
- (C) rate = $k[A][B]^3$
- (D) rate = $k[A]^2[B]^2$
- (E) rate = $k[A]/[B]$

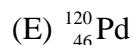
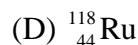
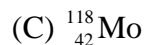
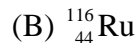
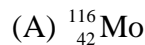
30. In the titration of a weak base of unknown concentration with a solution of a strong acid, a pH meter was used to follow the progress of the titration. Which of the following represents the graph of the data collected for this experiment?



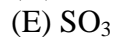
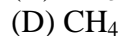
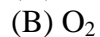


31.

What is the missing product in the nuclear reaction represented above?



32. The Lewis dot structure of which of the following molecules shows only one unshared pair of valence electrons around the central atom?



33. $\text{rate} = k[\text{A}]^2$

For the reaction whose rate law is given above, a plot of which of the following is a straight line?

(A) $[\text{A}]$ versus time

(B) $[\text{A}]$ versus $1/\text{time}$

(C) $1/[\text{A}]$ versus time

(D) $\ln [\text{A}]$ versus time

(E) $\ln [\text{A}]$ versus $1/\text{time}$

34. Which of the following must be true for a reaction that proceeds spontaneously from initial standard state conditions?

(A) ΔG° is positive and K_{eq} is greater than 1

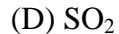
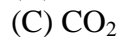
(B) ΔG° is positive and K_{eq} is less than 1

(C) ΔG° is negative and K_{eq} is greater than 1

(D) ΔG° is positive and K_{eq} is greater than 1

(E) ΔG° is equal to zero and K_{eq} is equal to 1

35. Which of the following compounds contains the most pi bonds?

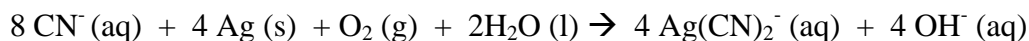


Question 36-37 refer to the following elements.

- (A) Potassium
- (B) Manganese
- (C) Bromine
- (D) Uranium
- (E) Chlorine

36. Is a liquid in its standard state at 298 K.

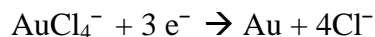
37. Reacts violently with water to form a strong base .



38. Which of the following is true regarding the reaction represented above?

- (A) The oxidation number of O does not change.
- (B) The oxidation number of H changes from -1 to +1.
- (C) The oxidation number of Ag changes from zero to -1.
- (D) The oxidation number of C is +4 in the cyanide ion.
- (E) This oxidation number of N is -3 in the cyanide ion.

Questions 39 - 40 refer to an electrolytic cell that involves the following half-reaction.



39. Which of the following occurs in the reaction?

- (A) Au is oxidized at the anode.
- (B) AuCl_4^- is reduced at the cathode.
- (C) Gold is converted from the -3 oxidation state to the 0 oxidation state.
- (D) Cl^- acts as a reducing agent.
- (E) Cl^- is oxidized at the anode.

40. A steady current of 2.0 amperes is passed through a gold-production cell for 10 minutes. Which of the following is the correct expression for calculating the number of grams of gold produced? (1 faraday = 96,500 coulombs)

(A) $\frac{(2)(10)(60)}{(197)(96,500)(3)}$

(B) $\frac{(2)(10)(96,500)}{(197)(60)}$

(C) $\frac{(2)(10)(60)(197)}{(3)(96,500)}$

(D) $\frac{(96,500)(197)}{(3)(2)(60)(10)}$

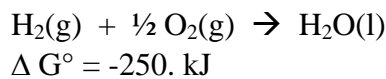
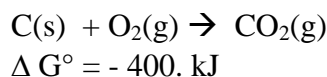
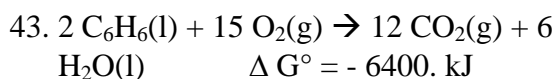
(E) $\frac{(3)(197)}{(2)(60)(10)(96,500)}$

41. The half-life for radioactive element Q is 5.0 min. What mass of Q was originally present in a sample if 80. grams is left after 45. minutes?

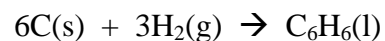
- (A) 2,560 grams
- (B) 5,120 grams
- (C) 10,240 grams
- (D) 20,480 grams
- (E) 40,960 grams

42. Which of the following is a correct interpretation of the results of Rutherford's experiments in which gold atoms were bombarded with alpha particles?

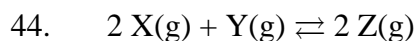
- (A) Electrons in atoms are negative.
- (B) The positive charge of an atom is found in a small dense region.
- (C) Atoms consist of mostly empty space.
- (D) Electrons are attracted to alpha particles.
- (E) Alpha particles are smaller than protons.



What is the standard free energy change for the reaction below, as calculated from the data above?



- (A) -250. kJ
- (B) -100. kJ
- (C) -50. kJ
- (D) 50. kJ
- (E) 100. kJ



When the concentration of substance Y in the reaction above is doubled, all other factors being held constant, it is found that the rate of the reaction quadruples. The most probable explanation for this observation is that

- (A) the order of the reaction with respect to substance Y is 2.
- (B) substance Y is not involved in each of the steps in the mechanism of the reaction.
- (C) substance Y is involved in the rate-determining step of the mechanism, but is not involved in subsequent steps.
- (D) substance Y is probably a catalyst and thus speeds up the rate of the reaction.
- (E) the reactant with the smallest coefficient in the balanced equation generally has the greatest effect on the rate of the reaction.

45. Appropriate laboratory procedures include which of the following?

- I. Calibrating a pH probe before using it.
- II. Lubricating glass tubing before inserting it into a stopper.
- III. For accurate results, waiting until warm or hot objects have reached room temperature before weighing them.

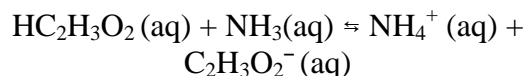
- (A) II only
- (B) I and II only
- (C) I and III only
- (D) II and III only
- (E) I, II, and III

46. Relatively slow rates of chemical reaction are associated with each of the following EXCEPT

- (A) The presence of a catalyst
- (B) Low reaction temperature
- (C) High concentration of products
- (D) High bond energy in reactant molecules
- (E) High activation energy

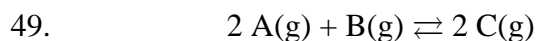
47. A 1.0 L sample of an aqueous solution contains 0.10 mol of $BaCl_2$ and 0.10 mol of $Ba_3(PO_4)_2$. What is the minimum number of moles of Na_2SO_4 that must be added to the solution in order to precipitate all of the Ba^{2+} as $BaSO_4(s)$? (Assume that $BaSO_4$ is insoluble.)

- (A) 0.10 mol
- (B) 0.20 mol
- (C) 0.30 mol
- (D) 0.40 mol
- (E) 0.60 mol



48. The reaction represented above has an equilibrium constant equal to 8.4×10^2 at 500K. Which of the following can be concluded from this information?

- A) $NH_3(aq)$ is a stronger base than $C_2H_3O_2^-(aq)$
- B) $NH_4^+(aq)$ is a stronger acid than $HC_2H_3O_2(aq)$
- C) The conjugate base of $NH_3(aq)$ is $C_2H_3O_2^-(aq)$
- D) The equilibrium constant will increase with an increase in temperature.
- E) The reaction is exothermic.



When 0.60 mole of A and 0.75 mole of B are placed in an evacuated 1.00-liter flask, the reaction represented above occurs. After the reactants and the product reach equilibrium and the initial temperature is restored, the flask is found to contain 0.30 mole of product C. Based on these results, the equilibrium constant, K_c for the reaction is

- (A) 0.60
- (B) 0.90
- (C) 1.7
- (D) 3.4
- (E) 6.0



Which of the following does not describe any of the molecules above?

- (A) Linear
- (B) Octahedral
- (C) Square planar
- (D) Tetrahedral
- (E) Trigonal bipyramidal

51. What is the pH of a 1.0×10^{-3} molar solution of a monoprotic acid with a K_a equal to 6.5×10^{-10} .)

- (A) 3
- (B) Between 4 and 7
- (C) 7
- (D) Between 7 and 10
- (E) 10

52. The volume of distilled water that should be **added** to 10.0 mL of 6.00 M NaOH(aq) in order to prepare a 0.100 M NaOH(aq) solution is approximately

- A) 0.60 mL
- B) 5.9 mL
- C) 59.0 mL
- D) 590. mL
- E) 600. mL

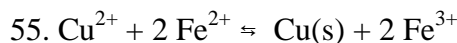
53. Appropriate uses of a visible-light spectrophotometer include which of the following?

- I. Determining the concentration of a solution of $\text{Zn}(\text{NO}_3)_2$
- II. Measuring the conductivity of a solution of KMnO_4
- III. Determining which ions are present in a solution that may contain Ni^{2+} , Co^{2+} , and Fe^{3+}

- (A) I only
- (B) II only
- (C) III only
- (D) I and II only
- (E) I and III only

54. Which of the following ions is the strongest Lewis acid?

- (A) K^+
- (B) F^-
- (C) ClO_4^-
- (D) Ca^{2+}
- (E) Al^{3+}

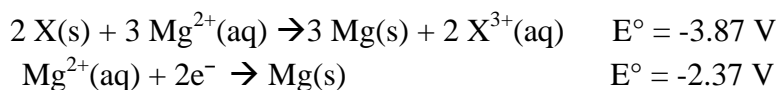


If the equilibrium constant for the reaction above is 2.5×10^{-4} , which of the following correctly describes the standard voltage, E° , and the standard free energy change, ΔG° , for this reaction?

- (A) E° and ΔG° are both zero.
- (B) E° and ΔG° are both positive.
- (C) E° and ΔG° are both negative.
- (D) E° is positive and ΔG° is negative.
- (E) E° is negative and ΔG° is positive.

56. Which of the following occurs when 0.10 M solutions of KSCN and $\text{Fe}(\text{NO}_3)_3$ are mixed?

- (A) A bright yellow precipitate forms and settles out.
- (B) The color of the solution becomes brick red.
- (C) The color of the solution turns from light blue to dark blue.
- (D) Bubbles of nitrogen dioxide gas form.
- (E) The pH of the solution decreases.



57. According to the information above, what is the standard reduction potential for the half-reaction $\text{X}^{3+}(\text{aq}) + 3 \text{e}^- \rightarrow \text{X}(\text{s})$?

- A) -1.50 V
- B) -0.50 V
- C) 0.05 V
- D) 1.50 V
- E) 6.24 V

58. Which of the following techniques is most appropriate for the recovery of solid NaCl from an aqueous solution of NaCl?

- (A) Distillation
- (B) Filtration
- (C) Electrolysis
- (D) Fractional crystallization
- (E) Evaporation to dryness

59. To determine the acid dissociation constant of a solid monoprotic acid, a student titrated a dry, weighed sample of the acid with standardized aqueous NaOH. Which of the following could explain why the student obtained a K_a value that was too large?

- I. Failure to rinse the buret with NaOH after washing it
- II. Not adding enough water to dissolve the acid
- III. Addition of some base beyond the equivalence point

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

Ionization Energies for element Q (kJ mol^{-1})				
First	Second	Third	Fourth	Five
634	2178	13,296	15,780	17,935

60. The ionization energies for element Q are listed in the table above. On the basis of the data, element Q is most likely to be

- (A) K
- (B) Ca
- (C) Ga
- (D) Ge
- (E) As

61. Which, if any, of the following species is in the greatest concentration in a 0.500-molar solution of $\text{Ba}(\text{OH})_2$ in water?

- (A) $\text{Ba}(\text{OH})_2$ molecules
- (B) OH^- ions
- (C) BaOH^+ ions
- (D) H_3O^+ ions
- (E) All species are in equilibrium and therefore have the same concentrations.

62.

- I. Difference in temperature between boiling point of solvent and boiling point of solution.
- II. Molal boiling point elevation constant, K_b , for solvent.

In addition to the information above, which of the following gives the minimum data required to determine the molecular mass of a soluble molecular nonvolatile substance by the boiling point elevation technique?

- (A) Mass of solute
- (B) Density of solvent
- (C) Mass of solute and mass of solvent
- (D) Density of solution and volume of solution
- (E) Mass of solute, mass of solvent, and density of solvent

63. The simplest formula for a hydrocarbon that is 20.0 percent hydrogen by mass is

- (A) CH
- (B) CH_2
- (C) CH_3
- (D) C_2H_2
- (E) C_2H_3

64. What is the balanced net ionic equation for the reaction that occurs when an excess of ammonia gas is bubbled through a solution saturated with silver chloride?

- (A) $\text{Ag}^+ + \text{Cl}^- + \text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_4\text{Cl} + \text{AgOH}$
- (B) $\text{Ag}^+ + 2 \text{NH}_3 + 2 \text{H}_2\text{O} \rightarrow \text{Ag}(\text{OH})_2^- + 2 \text{NH}_4^+$
- (C) $\text{Ag}^+ + \text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{AgOH} + \text{NH}_4^+$
- (D) $\text{AgCl} + 2 \text{NH}_3 \rightarrow \text{Ag}(\text{NH}_3)_2^+ + \text{Cl}^-$
- (E) $2\text{Ag}^+ + 2 \text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{Ag}_2\text{O} + 2 \text{NH}_4^+$

65. Which of the following does NOT behave as an electrolyte when it is dissolved in water?

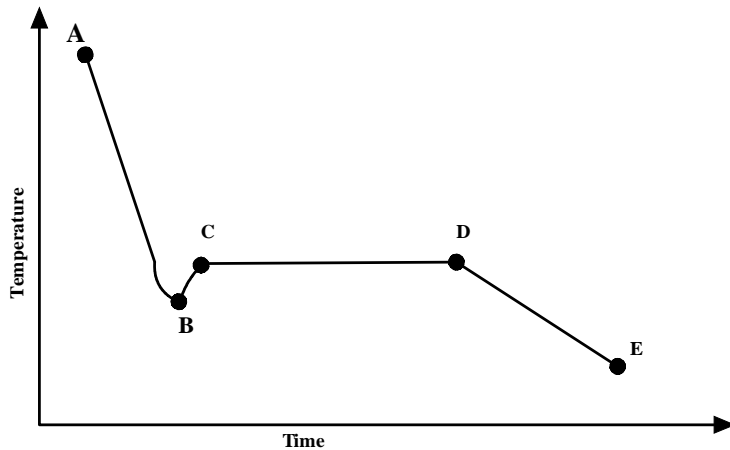
- (A) KCH_3COO
- (B) Na_2CO_3
- (C) NH_4Cl
- (D) CH_3COOH
- (E) $\text{C}_2\text{H}_5\text{OH}$

66. Which of the following acids can be oxidized to form a stronger acid?

- (A) $\text{H}_2\text{C}_2\text{O}_4$
- (B) HNO_2
- (C) H_2SO_4
- (D) H_3PO_4
- (E) $\text{HC}_2\text{H}_3\text{O}_2$

67. What is the final concentration of barium ions, $[\text{Ba}^{2+}]$, in solution when 100. mL of 0.10 M $\text{Ba}(\text{NO}_3)_2$ (aq) is mixed with 100. mL of 0.060 M MgSO_4 (aq)?

- A) 0.00 M
- B) 0.02 M
- C) 0.06 M
- D) 0.08 M
- E) 0.16 M

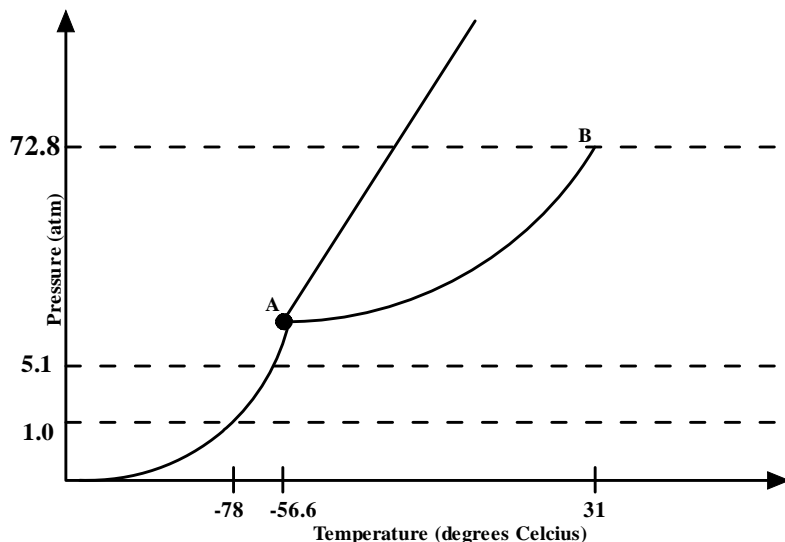


68. The cooling curve for a pure substance as it changes from a liquid to a solid is shown above. The part of the curve that represents only the solid phase is

- (A) point B only
- (B) point C only
- (C) point D only
- (D) all points on the curve between C and D
- (E) all points on the curve between D and E

69. A sample of 0.010 mole of nitrogen dioxide gas is confined at 127 °C and 2.5 atmospheres. What would be the pressure of this sample at 27 °C and the same volume?

- (A) 0.033 atm
- (B) 0.33 atm
- (C) 0.53 atm
- (D) 1.25 atm
- (E) 1.88 atm



70. The normal boiling point of the substance represented by the phase diagram above is

- (A) $-78\text{ }^{\circ}\text{C}$
- (B) $-56.6\text{ }^{\circ}\text{C}$
- (C) $31\text{ }^{\circ}\text{C}$
- (D) greater than $31\text{ }^{\circ}\text{C}$
- (E) not determinable from the diagram

71. The phase diagram above provides sufficient information for determining the

- (A) density of the substance
- (B) conditions necessary for sublimation
- (C) specific heat of the substance
- (D) latent heat of vaporization
- (E) latent heat of fusion

72. For the substance represented in the diagram, which of the phases is most dense and which is least dense at $-78\text{ }^{\circ}\text{C}$.

	Most Dense	Least Dense
(A)	Solid	Gas
(B)	Solid	Liquid
(C)	Liquid	Solid
(D)	Liquid	Gas
(E)	The diagram gives no information about densities.	

73. What mass of Al is produced when 0.500 mol of Al_2S_3 is reduced completely with excess H_2 ?

- (A) 13.5 g
- (B) 27.0 g
- (C) 54.0 g
- (D) 108 g
- (E) 216 g

74. When a 16.8-gram sample of an unknown mineral was dissolved in acid, 4.4 gram of CO_2 was generated. If the rock contained no carbonate other than MgCO_3 , what was the percent of MgCO_3 by mass in the limestone?

- (A) 33%
- (B) 50%
- (C) 67%
- (D) 80%
- (E) 100%

75. $\dots \text{Cr} + \dots \text{CrO}_4^{2-} + \dots \rightarrow \dots \text{Cr(OH)}_3$

If 1 mole of CrO_4^{2-} oxidizes Cr according to the reaction represented above, how many moles of Cr(OH)_3 can be formed?

- (A) 2
- (B) 3
- (C) 4
- (D) 5
- (E) 6