

CHEMISTRY

Section I

Time—1 hour and 30 minutes

NO CALCULATOR MAY BE USED WITH SECTION I.

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

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

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

Part A

Directions: Each set of lettered choices below refers to the numbered statements immediately following it. Select the one that is best in each case and then place the letter of your choice in the corresponding box on the student answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-4 refer to the following chemical compounds.

- (A) CH_4
- (B) CCl_3F
- (C) H_2S
- (D) H_2O_2
- (E) K_2CrO_4

1. Commonly used as a disinfectant for minor skin wounds
2. A refrigerant implicated in the thinning of the stratospheric ozone layer
3. A major component of the fuel known as natural gas
4. A yellow solid at room temperature and 1 atm

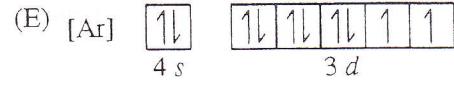
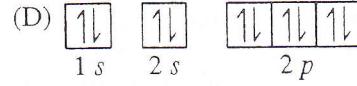
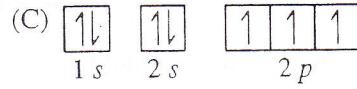
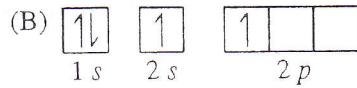
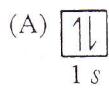
Questions 5-7 refer to the following molecules.

- (A) CO
- (B) CH_4
- (C) HF
- (D) PH_3
- (E) F_2

5. Contains two π -bonds
6. Has the highest dipole moment
7. Has a molecular geometry that is trigonal pyramidal

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Questions 8-11 refer to neutral atoms for which the atomic orbitals are represented below



8. Is in an excited state
9. Has exactly five valence electrons
10. Has the highest first ionization energy
11. Forms an aqueous cation that is colored

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Questions 12-15 refer to the chemical reactions represented below.

- (A) $\text{HC}_2\text{H}_3\text{O}_2(aq) + \text{NH}_3(aq) \rightarrow \text{C}_2\text{H}_3\text{O}_2^-(aq) + \text{NH}_4^+(aq)$
- (B) $\text{Ba}^{2+}(aq) + \text{SO}_4^{2-}(aq) \rightarrow \text{BaSO}_4(s)$
- (C) $\text{Zn(OH)}_2(s) + 2 \text{OH}^-(aq) \rightarrow [\text{Zn(OH)}_4]^{2-}(aq)$
- (D) $2 \text{K}(s) + \text{Br}_2(l) \rightarrow 2 \text{KBr}(s)$
- (E) $\text{N}_2\text{O}_4(g) \rightarrow 2 \text{NO}_2(g)$

12. An oxidation-reduction reaction

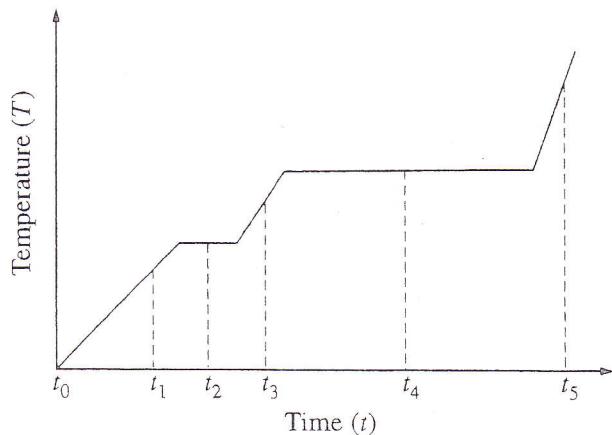
13. A precipitation reaction

14. A reaction in which a coordination complex is formed

15. A Lewis acid-base reaction that is not a Brønsted-Lowry acid-base reaction

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Questions 16-17 refer to various points in time during an experiment conducted at 1.0 atm. Heat is added at a constant rate to a sample of a pure substance that is solid at time t_0 . The graph below shows the temperature of the sample as a function of time.



- (A) t_1
- (B) t_2
- (C) t_3
- (D) t_4
- (E) t_5

16. Time when the average distance between the particles is greatest
17. Time when the temperature of the substance is between its melting point and its boiling point

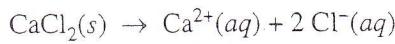
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Part B

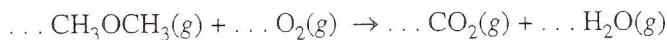
Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

18. Which of the following is the correct name for the compound with formula Ca_3P_2 ?
- (A) Tricalcium diphosphorus
(B) Calcium phosphite
(C) Calcium phosphate
(D) Calcium diphosphate
(E) Calcium phosphide
19. What mass of KBr (molar mass 119 g mol^{-1}) is required to make $250. \text{ mL}$ of a 0.400 M KBr solution?
- (A) 0.595 g
(B) 1.19 g
(C) 2.50 g
(D) 11.9 g
(E) 47.6 g
20. The value of the acid-dissociation constant, K_a , for a weak monoprotic acid HA is 2.5×10^{-6} . The pH of 0.40 M HA is closest to
- (A) 2.0
(B) 3.0
(C) 4.0
(D) 6.0
(E) 8.0
21. Which of the systems in equilibrium represented below will exhibit a shift to the left (toward reactants) when the pressure on the system is increased by reducing the volume of the system? (Assume that temperature is constant.)
- (A) $2 \text{ Mg}(s) + \text{O}_2(g) \rightleftharpoons 2 \text{ MgO}(s)$
(B) $\text{SF}_4(g) + \text{F}_2(g) \rightleftharpoons \text{SF}_6(g)$
(C) $\text{H}_2(g) + \text{Br}_2(g) \rightleftharpoons 2 \text{ HBr}(g)$
(D) $\text{N}_2(g) + 3 \text{ H}_2(g) \rightleftharpoons 2 \text{ NH}_3(g)$
(E) $\text{SO}_2\text{Cl}_2(g) \rightleftharpoons \text{SO}_2(g) + \text{Cl}_2(g)$
22. The standard enthalpy of formation, ΔH_f° , of $\text{HI}(g)$ is $+26 \text{ kJ mol}^{-1}$. Which of the following is the approximate mass of $\text{HI}(g)$ that must decompose into $\text{H}_2(g)$ and $\text{I}_2(s)$ to release $500. \text{ kJ}$ of energy?
- (A) 250 g
(B) 650 g
(C) $1,300 \text{ g}$
(D) $2,500 \text{ g}$
(E) $13,000 \text{ g}$

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23. For the process of solid calcium chloride dissolving in water, represented above, the entropy change might be expected to be positive. However, ΔS for the process is actually negative. Which of the following best helps to account for the net loss of entropy?
- (A) Cl^- ions are much larger in size than Ca^{2+} ions.
 - (B) The particles in solid calcium chloride are more ordered than are particles in amorphous solids.
 - (C) Water molecules in the hydration shells of Ca^{2+} and Cl^- ions are more ordered than they are in the pure water.
 - (D) The $\text{Ca}^{2+}(aq)$ and $\text{Cl}^-(aq)$ ions are more free to move around in solution than they are in $\text{CaCl}_2(s)$.
 - (E) In the solution, the average distance between $\text{Ca}^{2+}(aq)$ and $\text{Cl}^-(aq)$ is greater than the average distance between Ca^{2+} and Cl^- in $\text{CaCl}_2(s)$.
-



24. When the equation above is balanced using the lowest whole-number coefficients, the coefficient for $\text{O}_2(g)$ is
- (A) 6
 - (B) 4
 - (C) 3
 - (D) 2
 - (E) 1

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25. For which of the following processes does entropy decrease ($\Delta S < 0$)?

- (A) $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l)$
- (B) $\text{Br}_2(l) \rightarrow \text{Br}_2(g)$
- (C) Crystallization of $\text{I}_2(s)$ from an ethanol solution
- (D) Thermal expansion of a balloon filled with $\text{CO}_2(g)$
- (E) Mixing of equal volumes of $\text{H}_2\text{O}(l)$ and $\text{CH}_3\text{OH}(l)$

26. In a laboratory, a student wants to quantitatively collect the CO_2 gas generated by adding $\text{Na}_2\text{CO}_3(s)$ to 2.5 M HCl. The student sets up the apparatus to collect the CO_2 gas over water. The volume of collected gas is much less than the expected volume because CO_2 gas

- (A) is very soluble in water
- (B) is produced at a low pressure
- (C) is more dense than water vapor
- (D) has a larger molar mass than that of N_2 gas, the major component of air
- (E) has a slower average molecular speed than water vapor at the same temperature

27. What mass of $\text{Cu}(s)$ would be produced if 0.40 mol of $\text{Cu}_2\text{O}(s)$ was reduced completely with excess $\text{H}_2(g)$?

- (A) 13 g
- (B) 25 g
- (C) 38 g
- (D) 51 g
- (E) 100 g

28. Which of the following is a formula for an ether?

- (A) $\begin{array}{c} \text{H} & \text{O} & \text{H} \\ | & \parallel & | \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{H} \\ | & & | \\ \text{H} & & \text{H} \end{array}$
- (B) $\begin{array}{c} \text{H} & \text{H} & \text{O} \\ | & | & \parallel \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{O} - \text{H} \\ | & | \\ \text{H} & \text{H} \end{array}$
- (C) $\begin{array}{c} \text{H} & \text{H} & \text{H} \\ | & | & | \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{O} - \text{H} \\ | & | & | \\ \text{H} & \text{H} & \text{H} \end{array}$
- (D) $\begin{array}{c} \text{H} & \text{H} & \text{O} \\ | & | & \parallel \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{H} \\ | & | \\ \text{H} & \text{H} \end{array}$
- (E) $\begin{array}{c} \text{H} & \text{H} & & \text{H} \\ | & | & & | \\ \text{H} - \text{C} - \text{C} - \text{O} - \text{C} - \text{H} \\ | & | & & | \\ \text{H} & \text{H} & & \text{H} \end{array}$

Gas	Amount
Ar	0.35 mol
CH_4	0.90 mol
N_2	0.25 mol

29. Three gases in the amounts shown in the table above are added to a previously evacuated rigid tank. If the total pressure in the tank is 3.0 atm at 25°C, the partial pressure of $\text{N}_2(g)$ in the tank is closest to

- (A) 0.75 atm
- (B) 0.50 atm
- (C) 0.33 atm
- (D) 0.25 atm
- (E) 0.17 atm

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30. Which of the following best explains why the normal boiling point of $\text{CCl}_4(l)$ (350 K) is higher than the normal boiling point of $\text{CF}_4(l)$ (145 K) ?

- (A) The C–Cl bonds in CCl_4 are less polar than the C–F bonds in CF_4 .
- (B) The C–Cl bonds in CCl_4 are weaker than the C–F bonds in CF_4 .
- (C) The mass of the CCl_4 molecule is greater than that of the CF_4 molecule.
- (D) The electron cloud of the CCl_4 molecule is more polarizable than that of the CF_4 molecule.
- (E) The bonds in the CCl_4 molecule are covalent, whereas the bonds in the CF_4 molecule are ionic.

31. At which of the following temperatures and pressures would a real gas be most likely to deviate from ideal behavior?

Temperature (K)	Pressure (atm)
(A) 100	50
(B) 200	5
(C) 300	0.01
(D) 500	0.01
(E) 500	1

32. After 195 days, a 10.0 g sample of pure ^{95}Zr has decayed to the extent that only 1.25 g of the original ^{95}Zr remains. The half-life of ^{95}Zr is closest to

- (A) 195 days
- (B) 97.5 days
- (C) 65.0 days
- (D) 48.8 days
- (E) 24.4 days

33. Which of the following would produce the LEAST mass of CO_2 if completely burned in excess oxygen gas?

- (A) 10.0 g CH_4
- (B) 10.0 g CH_3OH
- (C) 10.0 g C_2H_4
- (D) 10.0 g C_2H_6
- (E) 10.0 g $\text{C}_4\text{H}_5\text{OH}$

34. Which of the following substances exhibits significant hydrogen bonding in the liquid state?

- (A) CH_2F_2
- (B) N_2H_4
- (C) CH_3OCH_3
- (D) C_2H_4
- (E) C_2H_2

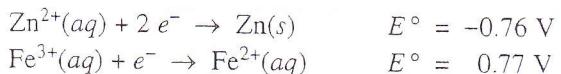
35. In an aqueous solution with a pH of 11.50 at 25°C, the molar concentration of $\text{OH}^-(aq)$ is approximately

- (A) $3.2 \times 10^{-12} M$
- (B) $3.2 \times 10^{-3} M$
- (C) $2.5 \times 10^{-1} M$
- (D) $2.5 M$
- (E) $3.2 \times 10^{11} M$

36. Which of the following changes to a reaction system in equilibrium would affect the value of the equilibrium constant, K_{eq} , for the reaction? (Assume in each case that all other conditions are held constant.)

- (A) Adding more of the reactants to the system
- (B) Adding a catalyst for the reaction to the system
- (C) Increasing the temperature of the system
- (D) Increasing the pressure on the system
- (E) Removing some of the reaction products from the system

Questions 37-38 refer to a galvanic cell constructed using two half-cells and based on the two half-reactions represented below.



37. As the cell operates, ionic species that are found in the half-cell containing the cathode include which of the following?

- I. $\text{Zn}^{2+}(aq)$
- II. $\text{Fe}^{2+}(aq)$
- III. $\text{Fe}^{3+}(aq)$

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

38. What is the standard cell potential for the galvanic cell?

- (A) -0.01 V
- (B) 0.01 V
- (C) 0.78 V
- (D) 1.53 V
- (E) 2.31 V

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Ionization Energies for Element X

	1st	2nd	3rd	4th	5th	6th	7th
Ionization Energy (kJ mol ⁻¹)	787	1,580	3,200	4,400	16,000	20,000	24,000

39. The first seven ionization energies of element X are shown in the table above. On the basis of these data, element X is most likely a member of which of the following groups (families) of elements?

- (A) Alkaline earth metals
- (B) Boron group
- (C) Carbon group
- (D) Nitrogen group
- (E) Halogen group

40. Which of the following particles is emitted by an atom of ^{39}Ca when it decays to produce an atom of ^{39}K ?

- (A) $^{ 4}_{\text{2}}\text{He}$
- (B) $^{ 1}_{\text{0}}\text{n}$
- (C) $^{ 1}_{\text{1}}\text{H}$
- (D) β^-
- (E) β^+

41. At approximately what temperature will 40. g of argon gas at 2.0 atm occupy a volume of 22.4 L?

- (A) 1,200 K
- (B) 600 K
- (C) 550 K
- (D) 270 K
- (E) 140 K

42. Which of the following aqueous solutions has the highest boiling point at 1.0 atm?

- (A) 0.20 M CaCl_2
- (B) 0.25 M Na_2SO_4
- (C) 0.30 M NaCl
- (D) 0.30 M KBr
- (E) 0.40 M $\text{C}_6\text{H}_{12}\text{O}_6$

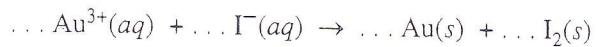
43. A certain reaction is spontaneous at temperatures below 400. K but is not spontaneous at temperatures above 400. K. If ΔH° for the reaction is $-20.$ kJ mol⁻¹ and it is assumed that ΔH° and ΔS° do not change appreciably with temperature, then the value of ΔS° for the reaction is

- (A) $-50.$ J mol⁻¹ K⁻¹
- (B) $-20.$ J mol⁻¹ K⁻¹
- (C) -0.050 J mol⁻¹ K⁻¹
- (D) $20.$ J mol⁻¹ K⁻¹
- (E) $8,000$ J mol⁻¹ K⁻¹

44. A sample of a solution of RbCl (molar mass 121 g mol⁻¹) contains 11.0 percent RbCl by mass. From the following information, what is needed to determine the molarity of RbCl in the solution?

- I. Mass of the sample
 - II. Volume of the sample
 - III. Temperature of the sample
- (A) I only
 - (B) II only
 - (C) I and II only
 - (D) II and III only
 - (E) I, II, and III

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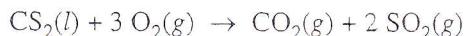
45. When the equation above is balanced using the lowest whole-number coefficients, the coefficient for $\text{I}_2(s)$ is

- (A) 8
 - (B) 6
 - (C) 4
 - (D) 3
 - (E) 2
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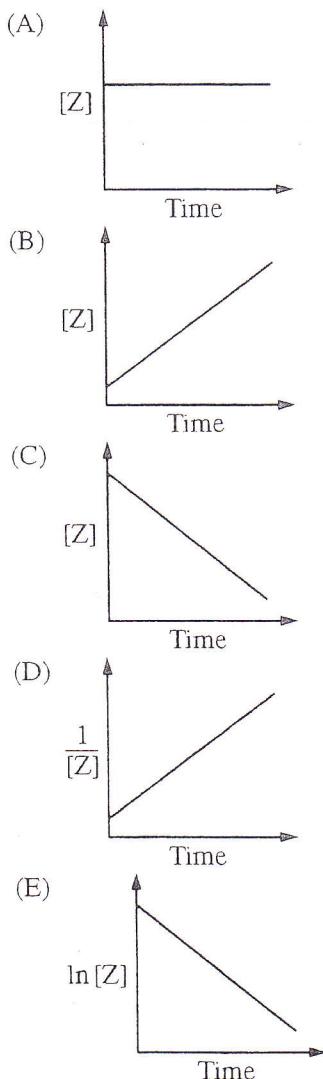
46. A closed rigid container contains distilled water and $\text{N}_2(g)$ at equilibrium. Actions that would increase the concentration of $\text{N}_2(g)$ in the water include which of the following?

- I. Shaking the container vigorously
 - II. Raising the temperature of the water
 - III. Injecting more $\text{N}_2(g)$ into the container
- (A) I only
(B) II only
(C) III only
(D) I and II only
(E) I, II, and III

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47. A pure substance Z decomposes into two products, X and Y , as shown by the equation above. Which of the following graphs of the concentration of Z versus time is consistent with the rate of the reaction being first order with respect to Z ?



48. When 0.60 mol of $CS_2(l)$ reacts as completely as possible with 1.5 mol of $O_2(g)$ according to the equation above, the total number of moles of reaction products is

- (A) 2.4 mol
 (B) 2.1 mol
 (C) 1.8 mol
 (D) 1.5 mol
 (E) 0.75 mol

Questions 49-50 refer to an experiment to determine the value of the heat of fusion of ice. A student used a calorimeter consisting of a polystyrene cup and a thermometer. The cup was weighed, then filled halfway with warm water, then weighed again. The temperature of the water was measured, and some ice cubes from a 0°C ice bath were added to the cup. The mixture was gently stirred as the ice melted, and the lowest temperature reached by the water in the cup was recorded. The cup and its contents were weighed again.

49. The purpose of weighing the cup and its contents again at the end of the experiment was to

- (A) determine the mass of ice that was added
 (B) determine the mass of the thermometer
 (C) determine the mass of water that evaporated
 (D) verify the mass of water that was cooled
 (E) verify the mass of the calorimeter cup

50. Suppose that during the experiment, a significant amount of water from the ice bath adhered to the ice cubes. How does this affect the calculated value for the heat of fusion of ice?

- (A) The calculated value is too large because less warm water had to be cooled.
 (B) The calculated value is too large because more cold water had to be heated.
 (C) The calculated value is too small because less ice was added than the student assumed.
 (D) The calculated value is too small because the total mass of the calorimeter contents was too large.
 (E) There is no effect on the calculated value because the water adhered to the ice cubes was at 0°C .

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51. Which of the following molecules contains bonds that have a bond order of 1.5?

- (A) N_2
- (B) O_3
- (C) NH_3
- (D) CO_2
- (E) CH_2CH_2

52. Of the following metals, which reacts violently with water at 298 K?

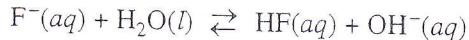
- (A) Au
- (B) Ag
- (C) Cu
- (D) Mg
- (E) Rb

53. Heat energy is added slowly to a pure solid covalent compound at its melting point. About half of the solid melts to become a liquid. Which of the following must be true about this process?

- (A) Covalent bonds are broken as the solid melts.
- (B) The temperature of the solid/liquid mixture remains the same while heat is being added.
- (C) The intermolecular forces present among molecules become zero as the solid melts.
- (D) The volume of the compound increases as the solid melts to become a liquid.
- (E) The average kinetic energy of the molecules becomes greater as the molecules leave the solid state and enter the liquid state.

54. A steady electric current is passed through molten MgCl_2 for exactly 1.00 hour, producing 243 g of Mg metal. If the same current is passed through molten AlCl_3 for 1.00 hour, the mass of Al metal produced is closest to

- (A) 27.0 g
- (B) 54.0 g
- (C) 120. g
- (D) 180. g
- (E) 270. g

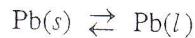


55. Which of the following species, if any, acts as a Brønsted-Lowry base in the reversible reaction represented above?

- (A) $\text{HF}(\text{aq})$
- (B) $\text{H}_2\text{O}(l)$
- (C) $\text{F}^-(\text{aq})$ only
- (D) Both $\text{F}^-(\text{aq})$ and $\text{OH}^-(\text{aq})$ act as Brønsted-Lowry bases.
- (E) No species acts as a Brønsted-Lowry base.

56. What is the empirical formula of a hydrocarbon that is 10.0 percent hydrogen by mass?

- (A) CH_3
 - (B) C_2H_5
 - (C) C_3H_4
 - (D) C_4H_9
 - (E) C_9H_{10}
-



57. Which of the following is true for the process represented above at 327°C and 1 atm? (The normal melting point of $\text{Pb}(s)$ is 327°C.)

- (A) $\Delta H = 0$
- (B) $T\Delta S = 0$
- (C) $\Delta S < 0$
- (D) $\Delta H = T\Delta G$
- (E) $\Delta H = T\Delta S$

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58. The equilibrium system represented above is contained in a sealed, rigid vessel. Which of the following will increase if the temperature of the mixture is raised?

- (A) $[\text{N}_2(g)]$
 - (B) The rate of the forward reaction only
 - (C) The rate of the reverse reaction only
 - (D) The rates of both the forward and reverse reactions
 - (E) The total number of moles of gas in the vessel
-

59. If a metal X forms an ionic chloride with the formula XCl_3 , then which of the following formulas is most likely to be that of a stable sulfide of X?

- (A) XS_2
- (B) X_2S_3
- (C) XS_6
- (D) $\text{X}(\text{SO}_3)_3$
- (E) $\text{X}_2(\text{SO}_3)_3$

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Questions 60-61 refer to the figures below. The figures show portions of a buret used in a titration of an acid solution of known concentration with a saturated solution of $\text{Ba}(\text{OH})_2$. Figures 1 and 2 show the level of the $\text{Ba}(\text{OH})_2$ solution at the start and at the endpoint of the titration, respectively. Phenolphthalein was used as the indicator for the titration.

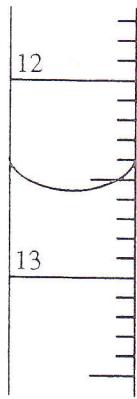


Figure 1

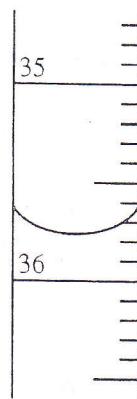
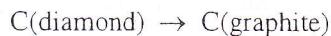


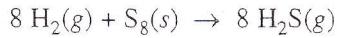
Figure 2

60. What is the evidence that the endpoint of the titration has been reached?
- (A) The color of the solution in the buret changes from pink to colorless.
 - (B) The color of the solution in the buret changes from blue to red.
 - (C) The color of the contents of the flask below the buret changes from colorless to pink.
 - (D) The color of the contents of the flask below the buret changes from blue to red.
 - (E) The contents of the flask below the buret change from clear to cloudy.
61. The volume of saturated $\text{Ba}(\text{OH})_2$ used to neutralize the acid was closest to
- (A) 6.60 mL
 - (B) 22.80 mL
 - (C) 23.02 mL
 - (D) 23.20 mL
 - (E) 29.80 mL

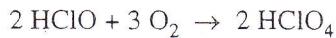
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62. For the reaction represented above, the standard Gibbs free energy change, ΔG_{298}° , has a value of $-2.90 \text{ kJ mol}^{-1}$. Which of the following best accounts for the observation that the reaction does NOT occur (i.e., diamond is stable) at 298 K and 1.00 atm?
- (A) ΔS° for the reaction is positive.
(B) The activation energy, E_a , for the reaction is very large.
(C) The reaction is slightly exothermic ($\Delta H^\circ < 0$).
(D) Diamond has a density greater than that of graphite.
(E) Diamond has a heat capacity lower than that of graphite.
-



63. When 25.6 g of $\text{S}_8(s)$ (molar mass 256 g mol^{-1}) reacts completely with an excess of $\text{H}_2(g)$ according to the equation above, the volume of $\text{H}_2\text{S}(g)$, measured at 0°C and 1.00 atm, produced is closest to
- (A) 30 L
(B) 20 L
(C) 10 L
(D) 5 L
(E) 2 L
-



64. As the reaction represented above proceeds to the right, the oxidation number of chlorine changes from
- (A) -1 to +3
(B) -1 to +5
(C) +1 to +5
(D) +1 to +7
(E) +3 to +7

65. By mixing only 0.15 M HCl and 0.25 M HCl, it is possible to create all of the following solutions EXCEPT

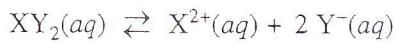
- (A) 0.23 M HCl
(B) 0.21 M HCl
(C) 0.18 M HCl
(D) 0.16 M HCl
(E) 0.14 M HCl

66. At 25°C a saturated solution of a metal hydroxide, M(OH)_2 , has a pH of 9.0. What is the value of the solubility-product constant, K_{sp} , of $\text{M(OH)}_2(s)$ at 25°C ?

- (A) 5.0×10^{-28}
(B) 1.0×10^{-27}
(C) 5.0×10^{-19}
(D) 5.0×10^{-16}
(E) 1.0×10^{-15}

GO ON TO THE NEXT PAGE.

67. A student weighs out 0.0154 mol of pure, dry NaCl in order to prepare a 0.154 M NaCl solution. Of the following pieces of laboratory equipment, which would be most essential for preparing the solution?
- (A) Large crucible with lid
(B) 50 mL volumetric pipet
(C) 100 mL Erlenmeyer flask
(D) 100 mL graduated beaker
(E) 100 mL volumetric flask
68. In which of the following are the chemical species correctly ordered from smallest radius to largest radius?
- (A) B < C < N
(B) Ar < Xe < Kr
(C) Cl < S < S²⁻
(D) Na < Na⁺ < K
(E) K⁺ < Ca²⁺ < K
69. A large piece of wood can burn slowly, but wood in the form of sawdust can combust explosively. The primary reason for the difference is that compared with a large piece of wood, sawdust
- (A) has a greater surface area per kilogram
(B) has a greater carbon content per kilogram
(C) absorbs more atmospheric moisture per kilogram
(D) contains more compounds that act as catalysts for combustion
(E) contains more compounds that have higher heats of combustion
70. Of the following elements, which would be expected to have chemical properties most similar to those of sulfur, S?
- (A) Br
(B) Cl
(C) N
(D) P
(E) Se
71. When a solution is formed by adding some methanol, CH₃OH, to water, processes that are endothermic include which of the following?
- I. Methanol molecules move water molecules apart as the methanol goes into solution.
II. Water molecules move methanol molecules apart as the methanol goes into solution.
III. Intermolecular attractions form between molecules of water and methanol as the methanol goes into solution.
- (A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III
72. Of the following gases, which has the greatest average molecular speed at 298 K?
- (A) Cl₂(g)
(B) NO(g)
(C) H₂S(g)
(D) HCN(g)
(E) PH₃(g)
73. Types of hybridization exhibited by carbon atoms in a molecule of propyne, CH₃CCH, include which of the following?
- I. sp
II. sp²
III. sp³
- (A) I only
(B) III only
(C) I and III only
(D) II and III only
(E) I, II, and III



74. A soluble compound XY_2 dissociates in water according to the equation above. In a 0.050 m solution of the compound, the $XY_2(aq)$ species is 40.0 percent dissociated. In the solution, the number of moles of particles of solute per 1.0 kg of water is closest to
- (A) 0.15
(B) 0.090
(C) 0.070
(D) 0.040
(E) 0.020

75. In which of the following processes are covalent bonds broken?
- (A) Solid silver melts.
(B) Solid potassium chloride melts.
(C) Solid carbon (graphite) sublimes.
(D) Solid iodine sublimes.
(E) Glucose dissolves in water.

END OF SECTION I

**IF YOU FINISH BEFORE TIME IS CALLED,
YOU MAY CHECK YOUR WORK ON THIS SECTION.**

DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.

AP® Chemistry
Multiple-Choice Answer Key

No.	Correct Answer
1	D
2	B
3	A
4	E
5	A
6	C
7	D
8	B
9	C
10	A
11	E
12	D
13	B
14	C
15	C
16	E
17	C
18	E
19	D
20	B
21	E
22	D
23	C
24	C
25	C
26	A
27	D
28	E
29	B
30	D

No.	Correct Answer
31	A
32	C
33	B
34	B
35	B
36	C
37	E
38	D
39	C
40	E
41	C
42	B
43	A
44	C
45	D
46	C
47	E
48	D
49	A
50	C
51	B
52	E
53	B
54	D
55	D
56	C
57	E
58	D
59	B
60	C

No.	Correct Answer
61	D
62	B
63	B
64	D
65	E
66	D
67	E
68	C
69	A
70	E
71	C
72	D
73	C
74	B
75	C