99

CHEMISTRY

SECTION I

Time — 1 hour and 30 minutes

NO CALCULATORS 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	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 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 9-12 refer to aqueous solutions containing 1:1 mole ratios of the following pairs of substances. Assume all concentrations are 1 M.

(A) NH_3 and NH_4Cl
(B) H_3PO_4 and NaH_2PO_4
(C) HCl and NaCl
(D) NaOH and NH_3
(E) NH_3 and $HC_2H_3O_2$ (acetic acid)

C 9. The solution with the lowest pH HCl / NaCl

F 10. The most nearly neutral solution NH_3 / CH_3COOH

A 11. A buffer at a pH > 8 NH_3 / NH_4^+

B 12. A buffer at a pH < 6 H_3PO_4 / $H_2PO_4^-$

Questions 13-16 refer to the following descriptions of bonding in different types of solids.

(A) Lattice of positive and negative ions held together by electrostatic forces
(B) Closely packed lattice with delocalized electrons throughout
(C) Strong single covalent bonds with weak intermolecular forces
(D) Strong multiple covalent bonds (including π-bonds) with weak intermolecular forces
(E) Macromolecules held together with strong polar bonds

A 13. Cesium chloride, $CsCl(s)$

B 14. Gold, $Au(s)$

D 15. Carbon dioxide, $CO_2(s)$

Questions 1-4 refer to the following types of energy.

(A) Activation energy
(B) Free energy
(C) Ionization energy
(D) Kinetic energy
(E) Lattice energy

C 1. The energy required to convert a ground-state atom in the gas phase to a gaseous positive ion

E 2. The energy change that occurs in the conversion of an ionic solid to widely separated gaseous ions

B 3. The energy in a chemical or physical change that is available to do useful work

A 4. The energy required to form the transition state in a chemical reaction

Questions 5-8 refer to atoms for which the occupied atomic orbitals are shown below.

(A) 1s ⇅ 2s ↑
(B) 1s ⇅ 2s ⇅
(C) 1s ⇅ 2s ⇅ 2p ↑ ↑ _
(D) 1s ⇅ 2s ⇅ 2p ⇅ ⇅ ⇅
(E) [Ar] 4s ⇅ 3d ⇅ ↑ ↑ ↑ ↑

D 5. Represents an atom that is chemically unreactive

A 6. Represents an atom in an excited state

C 7. Represents an atom that has four valence electrons

F 8. Represents an atom of a transition metal

Questions 17-18 refer to the following elements.

(A) Lithium
(B) Nickel
(C) Bromine
(D) Uranium
(E) Fluorine

E 17. Is a gas in its standard state at 298 K

A 18. Reacts with water to form a strong base

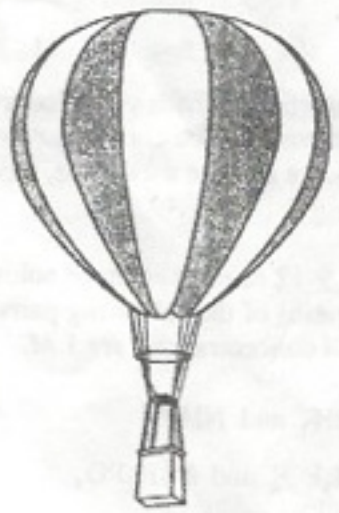
$Li + H_2O = LiOH$

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.

19. Which of the following best describes the role of the spark from the spark plug in an automobile engine?

(A) The spark decreases the energy of activation for the slow step.
(B) The spark increases the concentration of the volatile reactant.
C (C) The spark supplies some of the energy of activation for the combustion reaction.
(D) The spark provides a more favorable activated complex for the combustion reaction.
(E) The spark provides the heat of vaporization for the volatile hydrocarbon.



20. What mass of Au is produced when 0.0500 mol of Au_2S_3 is reduced completely with excess H_2?

B (A) 9.85 g
(B) 19.7 g
(C) 24.5 g
(D) 39.4 g
(E) 48.9 g

$.05\ Au_2S_3 \times \frac{2\ mol}{1\ mol} \times \frac{196.97}{1\ mol}$

21. When a solution of sodium chloride is vaporized in a flame, the color of the flame is

B (A) blue
(B) yellow
(C) green
(D) violet
(E) white

Na^+

22. Of the following reactions, which involves the largest decrease in entropy?

E (A) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

(B) $2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$

(C) $Pb(NO_3)_2(s) + 2\ KI(s) \rightarrow PbI_2(s) + 2\ KNO_3(s)$

(D) $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$

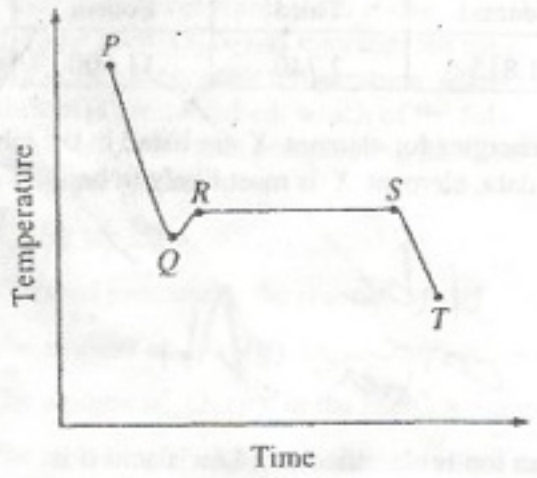
(E) $4\ La(s) + 3\ O_2(g) \rightarrow 2\ La_2O_3(s)$

23. A hot-air balloon, shown above, rises. Which of the following is the best explanation for this observation?

(A) The pressure on the walls of the balloon increases with increasing temperature.
(B) The difference in temperature between the air inside and outside the balloon produces convection currents.
(C) The cooler air outside the balloon pushes in on the walls of the balloon.
E (D) The rate of diffusion of cooler air is less than that of warmer air.
(E) The air density inside the balloon is less than that of the surrounding air.

24. The safest and most effective emergency procedure to treat an acid splash on skin is to do which of the following immediately?

(A) Dry the affected area with paper towels
(B) Sprinkle the affected area with powdered $Na_2SO_4(s)$
(C) Flush the affected area with water and then with a dilute NaOH solution
D (D) Flush the affected area with water and then with a dilute $NaHCO_3$ solution
(E) Flush the affected area with water and then with a dilute vinegar solution



25. The cooling curve for a pure substance as it changes from a liquid to a solid is shown above. The solid and the liquid coexist at

(A) point Q only
(B) point R only
(C) all points on the curve between Q and S
(D) all points on the curve between R and T
(E) no point on the curve

26. When the equation above is balanced and all coefficients are reduced to their lowest whole-number terms, the coefficient for $O_2(g)$ is

(A) 6
(B) 7
(C) 12
(D) 14
(E) 28

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

I. Determining the concentration of a solution of $Cu(NO_3)_2$
II. Measuring the conductivity of a solution of $KMnO_4$
III. Determining which ions are present in a solution that may contain Na^+, Mg^{2+}, Al^{3+}

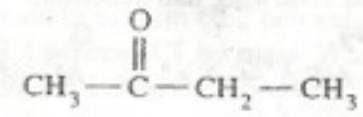
(A) I only
(B) II only
(C) III only
(D) I and II only
(E) I and III only

$\ldots C_{10}H_{12}O_4S(s) + \ldots O_2(g) \rightarrow \ldots CO_2(g) + \ldots SO_2(g) + \ldots H_2O(g)$

28. The melting point of MgO is higher than that of NaF. Explanations for this observation include which of the following?

I. Mg^{2+} is more positively charged than Na^+.
II. O^{2-} is more negatively charged than F^-.
III. The O^{2-} ion is smaller than the F^- ion.

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



29. The organic compound represented above is an example of

(A) an organic acid
(B) an alcohol
(C) an ether
(D) an aldehyde
(E) a ketone

$H_2Se(g) + 4\ O_2F_2(g) \rightarrow SeF_6(g) + 2\ HF(g) + 4\ O_2(g)$

30. 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 F changes from $+1$ to -1.
(D) The oxidation number of Se changes from -2 to $+6$.
(E) It is a disproportionation reaction for F.

31. If the temperature of an aqueous solution of NaCl is increased from 20°C to 90°C, which of the following statements is true?

(A) The density of the solution remains unchanged.
(B) The molarity of the solution remains unchanged.
(C) The molality of the solution remains unchanged.
(D) The mole fraction of solute decreases.
(E) The mole fraction of solute increases.

32. Types of hybridization exhibited by the C atoms in propene, CH_3CHCH_2, include which of the following?

I. sp
II. sp^2
III. sp^3

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

33. A 1.0 L sample of an aqueous solution contains 0.10 mol of NaCl and 0.10 mol of $CaCl_2$. What is the minimum number of moles of $AgNO_3$ that must be added to the solution in order to precipitate all of the Cl^- as AgCl(s) ? (Assume that AgCl is insoluble.)

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

Questions 34-35 refer to an electrolytic cell that involves the following half-reaction.

$$AlF_6^{3-} + 3\ e^- \rightarrow Al + 6\ F^-$$

34. Which of the following occurs in the reaction?

(A) AlF_6^{3-} is reduced at the cathode.
(B) Al is oxidized at the anode.
(C) Aluminum is converted from the −3 oxidation state to the 0 oxidation state.
(D) F^- acts as a reducing agent.
(E) F^- is reduced at the cathode.

35. A steady current of 10 amperes is passed through an aluminum-production cell for 15 minutes. Which of the following is the correct expression for calculating the number of grams of aluminum produced? (1 faraday = 96,500 coulombs)

(A) $\frac{(10)(15)(96,500)}{(27)(60)}$ g

(B) $\frac{(10)(15)(27)}{(60)(96,500)}$ g

(C) $\frac{(10)(15)(60)(27)}{(96,500)(3)}$ g

(D) $\frac{(96,500)(27)}{(10)(15)(60)(3)}$ g

(E) $\frac{(27)(3)}{(96,500)(10)(15)(60)}$ g

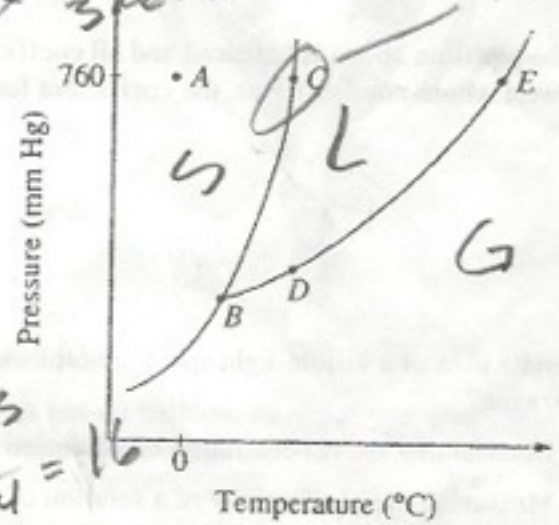
Ionization Energies for element X (kJ mol^{-1})				
First	Second	Third	Fourth	Fi
580	1,815	2,740	11,600	14,800

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

(A) Na
(B) Mg
(C) Al
(D) Si
(E) P

38. A molecule or an ion is classified as a Lewis acid if it

(A) accepts a proton from water
(B) accepts a pair of electrons to form a bond
(C) donates a pair of electrons to form a bond
(D) donates a proton to water
(E) has resonance Lewis electron-dot structures



39. The phase diagram for a pure substance is shown above. Which point on the diagram corresponds to the equilibrium between the solid and liquid phases at the normal melting point?

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

Experiment	Initial [NO] (mol L^{-1})	Initial [O_2] (mol L^{-1})	Initial Rate of Formation of NO_2 (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	0.40	8.0×10^{-3}

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

$$2\ NO(g) + O_2(g) \rightarrow NO_2(g)$$

(A) Rate = $k[NO][O_2]$
(B) Rate = $k[NO][O_2]^2$
(C) Rate = $k[NO]^2[O_2]$
(D) Rate = $k[NO]^2[O_2]^2$
(E) Rate = $k\frac{[NO]}{[O_2]}$

40. Of the following molecules, which has the largest dipole moment?

(A) CO
(B) CO_2
(C) O_2
(D) HF
(E) F_2

$$2\ SO_3(g) \rightleftarrows 2\ SO_2(g) + O_2(g)$$

After the equilibrium represented above is established, some pure $O_2(g)$ is injected into the reaction vessel at constant temperature. After equilibrium is reestablished, which of the following has a lower value compared to its value at the original equilibrium?

(A) K_{eq} for the reaction
(B) The total pressure in the reaction vessel
(C) The amount of $SO_3(g)$ in the reaction vessel
(D) The amount of $O_2(g)$ in the reaction vessel
(E) The amount of $SO_2(g)$ in the reaction vessel

$$\ldots Li_3N(s) + \ldots H_2O(l) \rightarrow \ldots Li^+(aq) + \ldots OH^-(aq) + \ldots NH_3(g)$$

42. When the equation above is balanced and all coefficients reduced to lowest whole-number terms, the coefficient for $OH^-(aq)$ is

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

43. A sample of 61.8 g of H_3BO_3, a weak acid, is dissolved in 1,000 g of water to make a 1.0-molal solution. Which of the following would be the best procedure to determine the molarity of the solution? (Assume no additional information is available.)

(A) Titration of the solution with standard acid
(B) Measurement of the pH with a pH meter
(C) Determination of the boiling point of the solution
(D) Measurement of the total volume of the solution
(E) Measurement of the specific heat of the solution

44. A rigid metal tank contains oxygen gas. Which of the following applies to the gas in the tank when additional oxygen is added at constant temperature?

(A) The volume of the gas increases.
(B) The pressure of the gas decreases.
(C) The average speed of the gas molecules remains the same.
(D) The total number of gas molecules remains the same.
(E) The average distance between the gas molecules increases.

45. What is the $H^+(aq)$ concentration in 0.05 M $HCN(aq)$? (The K_a for HCN is 5.0×10^{-10}.)

(A) 2.5×10^{-11} M
(B) 2.5×10^{-10} M
(C) 5.0×10^{-10} M
(D) 5.0×10^{-6} M
(E) 5.0×10^{-4} M

46. Which of the following occurs when excess concentrated $NH_3(aq)$ is mixed thoroughly with 0.1 M $Cu(NO_3)_2(aq)$?

(A) A dark red precipitate forms and settles out.
(B) Separate layers of immiscible liquids form with a blue layer on top.
(C) The color of the solution turns from light blue to dark blue.
(D) Bubbles of ammonia gas form.
(E) The pH of the solution decreases.

47. When hafnium metal is heated in an atmosphere of chlorine gas, the product of the reaction is found to contain 62.2 percent Hf by mass and 37.4 percent Cl by mass. What is the empirical formula for this compound?

(A) HfCl
(B) $HfCl_2$
(C) $HfCl_3$
(D) $HfCl_4$
(E) Hf_2Cl_3

48. If 87.5 percent of a sample of pure ^{131}I decays in 24 days, what is the half-life of ^{131}I?

(A) 6 days
(B) 8 days
(C) 12 days
(D) 14 days
(E) 21 days

49. Which of the following techniques is most appropriate for the recovery of solid KNO_3 from an aqueous solution of KNO_3?

(A) Paper chromatography
(B) Filtration
(C) Titration
(D) Electrolysis
(E) Evaporation to dryness

50. In the periodic table, as the atomic number increases from 11 to 17, what happens to the atomic radius?

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

51. 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) Atoms have equal numbers of positive and negative charges.
(B) Electrons in atoms are arranged in shells.
(C) Neutrons are at the center of an atom.
(D) Neutrons and protons in atoms have nearly equal mass.
(E) The positive charge of an atom is concentrated in a small region.

52. Under which of the following sets of conditions could the most $O_2(g)$ be dissolved in $H_2O(l)$?

	Pressure of $O_2(g)$ Above $H_2O(l)$ (atm)	Temperature of $H_2O(l)$ (°C)
(A)	5.0	80
(B)	5.0	20
(C)	1.0	80
(D)	1.0	20
(E)	0.5	20

$$W(g) + X(g) \rightarrow Y(g) + Z(g)$$

53. Gases W and X react in a closed, rigid vessel to form gases Y and Z according to the equation above. The initial pressure of $W(g)$ is 1.20 atm and that of $X(g)$ is 1.60 atm. No $Y(g)$ or $Z(g)$ is initially present. The experiment is carried out at constant temperature. What is the partial pressure of $Z(g)$ when the partial pressure of $W(g)$ has decreased to 1.0 atm?

(A) 0.20 atm
(B) 0.40 atm
(C) 1.0 atm
(D) 1.2 atm
(E) 1.4 atm

$$2\ NO(g) + O_2(g) \rightleftarrows 2\ NO_2(g) \qquad \Delta H < 0$$

54. Which of the following changes alone would cause a decrease in the value of K_{eq} for the reaction represented above?

(A) Decreasing the temperature
(B) Increasing the temperature
(C) Decreasing the volume of the reaction vessel
(D) Increasing the volume of the reaction vessel
(E) Adding a catalyst

$$10\ HI + 2\ KMnO_4 + 3\ H_2SO_4 \rightarrow 5\ I_2 + 2\ MnSO_4 + K_2SO_4 + 8\ H_2O$$

55. According to the balanced equation above, how many moles of HI would be necessary to produce 2.5 mol of I_2, starting with 4.0 mol of $KMnO_4$ and 3.0 mol of H_2SO_4?

(A) 20.
(B) 10.
(C) 8.0
(D) 5.0
(E) 2.5

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

(A) $Pb^{2+}(aq)$
(B) $Zn^{2+}(aq)$
(C) $CrO_4^{2-}(aq)$
(D) $SO_4^{2-}(aq)$
(E) $OH^-(aq)$

$$M(s) + 3\ Ag^+(aq) \rightarrow 3\ Ag(s) + M^{3+}(aq) \qquad E^\circ = +2.46\ V$$
$$Ag^+(aq) + e^- \rightarrow Ag(s) \qquad E^\circ = +0.80\ V$$

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

(A) −1.66 V
(B) −0.06 V
(C) 0.06 V
(D) 1.66 V
(E) 3.26 V

58. On a mountaintop, it is observed that wa… at 90°C, not at 100°C as at sea level. Thi… nomenon occurs because on the mountaintop

(A) equilibrium water vapor pressure is higher due to the higher atmospheric pressure
(B) equilibrium water vapor pressure is lower due to the higher atmospheric pressure
(C) equilibrium water vapor pressure equals the atmospheric pressure at a lower temperature
(D) water molecules have a higher average kinetic energy due to the lower atmospheric pressure
(E) water contains a greater concentration of dissolved gases

59. A 40.0 mL sample of 0.25 M KOH is added to 60.0 mL of 0.15 M $Ba(OH)_2$. What is the molar concentration of $OH^-(aq)$ in the resulting solution? (Assume that the volumes are additive.)

(A) 0.10 M
(B) 0.19 M
(C) 0.28 M
(D) 0.40 M
(E) 0.55 M

$$NH_4NO_3(s) \rightarrow N_2O(g) + 2\ H_2O(g)$$

60. A 0.03 mol sample of $NH_4NO_3(s)$ is placed in a 1 L evacuated flask, which is then sealed and heated. The $NH_4NO_3(s)$ decomposes completely according to the balanced equation above. The total pressure in the flask measured at 400 K is closest to which of the following? (The value of the gas constant, R, is 0.082 L atm mol^{-1} K^{-1}.)

(A) 3 atm
(B) 1 atm
(C) 0.5 atm
(D) 0.1 atm
(E) 0.03 atm

$$C_2H_4(g) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 2\ H_2O(g)$$

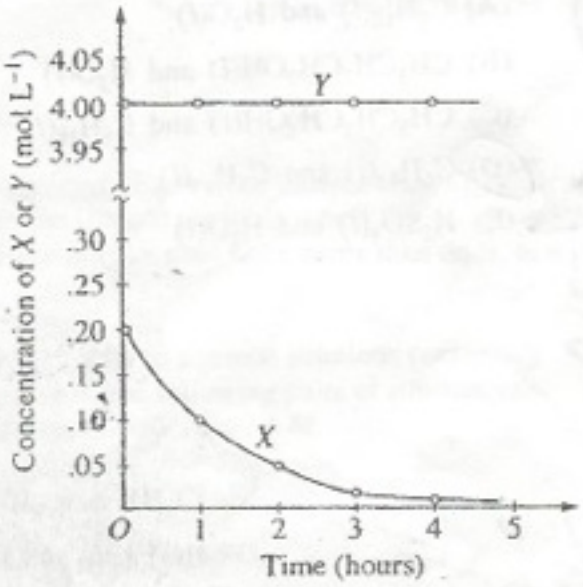
61. For the reaction of ethylene represented above, ΔH is −1,323 kJ. What is the value of ΔH if the combustion produced liquid water $H_2O(l)$, rather than water vapor $H_2O(g)$? (ΔH for the phase change $H_2O(g) \rightarrow H_2O(l)$ is −44 kJ mol^{-1}.)

(A) −1,235 kJ
(B) −1,279 kJ
(C) −1,323 kJ
(D) −1,367 kJ
(E) −1,411 kJ

$HC_2H_3O_2(aq) + CN^-(aq) \rightleftarrows HCN(aq) + C_2H_3O_2^-(aq)$

62. The reaction represented above has an equilibrium constant equal to 3.7×10^4. Which of the following can be concluded from this information?

(A) $CN^-(aq)$ is a stronger base than $C_2H_3O_2^-(aq)$.
(B) $HCN(aq)$ is a stronger acid than $HC_2H_3O_2(aq)$.
(C) The conjugate base of $CN^-(aq)$ is $C_2H_3O_2^-(aq)$.
(D) The equilibrium constant will increase with an increase in temperature.
(E) The pH of a solution containing equimolar amounts of $CN^-(aq)$ and $HC_2H_3O_2(aq)$ is 7.0.



63. The graph above shows the results of a study of the reaction of X with a large excess of Y to yield Z. The concentrations of X and Y were measured over a period of time. According to the results, which of the following can be concluded about the rate law for the reaction under the conditions studied?

(A) It is zero order in $[X]$.
(B) It is first order in $[X]$.
(C) It is second order in $[X]$.
(D) It is first order in $[Y]$.
(E) The overall order of the reaction is 2.

64. Equal numbers of moles of $He(g)$, $Ar(g)$, and $Ne(g)$ are placed in a glass vessel at room temperature. If the vessel has a pinhole-sized leak, which of the following will be true regarding the relative values of the partial pressures of the gases remaining in the vessel after some of the gas mixture has effused?

(A) $P_{He} < P_{Ne} < P_{Ar}$
(B) $P_{He} < P_{Ar} < P_{Ne}$
(C) $P_{Ne} < P_{Ar} < P_{He}$
(D) $P_{Ar} < P_{He} < P_{Ne}$
(E) $P_{He} = P_{Ar} = P_{Ne}$

65. Which of the following compounds is NOT appreciably soluble in water but is soluble in dilute hydrochloric acid?

(A) $Mg(OH)_2(s)$
(B) $(NH_4)_2CO_3(s)$
(C) $CuSO_4(s)$
(D) $(NH_4)_2SO_4(s)$
(E) $Sr(NO_3)_2(s)$

66. When solid ammonium chloride, $NH_4Cl(s)$, is added to water at 25°C, it dissolves and the temperature of the solution decreases. Which of the following is true for the values of ΔH and ΔS for the dissolving process?

	ΔH	ΔS
(A)	Positive	Positive
(B)	Positive	Negative
(C)	Positive	Equal to zero
(D)	Negative	Positive
(E)	Negative	Negative

67. What is the molar solubility in water of Ag_2CrO_4? (The K_{sp} for Ag_2CrO_4 is 8×10^{-12}.)

(A) $8 \times 10^{-12}\ M$
(B) $2 \times 10^{-12}\ M$
(C) $\sqrt{4 \times 10^{-12}}\ M$
(D) $\sqrt[3]{4 \times 10^{-12}}\ M$
(E) $\sqrt[3]{2 \times 10^{-12}}\ M$

68. In which of the following processes are covalent bonds broken?

(A) $I_2(s) \rightarrow I_2(g)$
(B) $CO_2(s) \rightarrow CO_2(g)$
(C) $NaCl(s) \rightarrow NaCl(l)$
(D) $C(\text{diamond}) \rightarrow C(g)$
(E) $Fe(s) \rightarrow Fe(l)$

69. What is the final concentration of barium ions, $[Ba^{2+}]$, in solution when 100. mL of 0.10 M $BaCl_2(aq)$ is mixed with 100. mL of 0.050 M $H_2SO_4(aq)$?

(A) 0.00 M
(B) 0.012 M
(C) 0.025 M
(D) 0.075 M
(E) 0.10 M

70. When 100 mL of 1.0 *M* Na_3PO_4 is mixed with 100 mL of 1.0 *M* $AgNO_3$, a yellow precipitate forms and $[Ag^+]$ becomes negligibly small. Which of the following is a correct listing of the ions remaining in solution in order of increasing concentration?

(A) $[PO_4^{3-}] < [NO_3^-] < [Na^+]$
(B) $[PO_4^{3-}] < [Na^+] < [NO_3^-]$
(C) $[NO_3^-] < [PO_4^{3-}] < [Na^+]$
(D) $[Na^+] < [NO_3^-] < [PO_4^{3-}]$
(E) $[Na^+] < [PO_4^{3-}] < [NO_3^-]$

71. In a qualitative analysis for the presence of Pb^{2+}, Fe^{2+}, and Cu^{2+} ions in aqueous solution, which of the following will allow the separation of Pb^{2+} from the other ions at room temperature?

(A) Adding dilute $Na_2S(aq)$ solution
(B) Adding dilute $HCl(aq)$ solution
(C) Adding dilute $NaOH(aq)$ solution
(D) Adding dilute $NH_3(aq)$ solution
(E) Adding dilute $HNO_3(aq)$ solution

72. After completing an experiment to determine gravimetrically the percentage of water in a hydrate, a student reported a value of 38 percent. The correct value for the percentage of water in the hydrate is 51 percent. Which of the following is the most likely explanation for this difference?

(A) Strong initial heating caused some of the hydrate sample to spatter out of the crucible.
(B) The dehydrated sample absorbed moisture after heating.
(C) The amount of the hydrate sample used was too small.
(D) The crucible was not heated to constant mass before use.
(E) Excess heating caused the dehydrated sample to decompose.

73. The volume of distilled water that should be added to 10.0 mL of 6.00 *M* $HCl(aq)$ in order to prepare a 0.500 *M* $HCl(aq)$ solution is approximately

(A) 50.0 mL
(B) 60.0 mL
(C) 100. mL
(D) 110. mL
(E) 120. mL

74. Which of the following gases deviates most from ideal behavior?

(A) SO_2
(B) Ne
(C) CH_4
(D) N_2
(E) H_2

75. Which of the following pairs of liquids forms the solution that is most ideal (most closely follows Raoult's law) ?

(A) $C_8H_{18}(l)$ and $H_2O(l)$
(B) $CH_3CH_2CH_2OH(l)$ and $H_2O(l)$
(C) $CH_3CH_2CH_2OH(l)$ and $C_8H_{18}(l)$
(D) $C_6H_{14}(l)$ and $C_8H_{18}(l)$
(E) $H_2SO_4(l)$ and $H_2O(l)$

20) $.05 \text{ mol } Au_2S_3 \times \frac{2 \text{ mol } Au^{3+}}{1 \text{ mol } Au_2S_3} \times$

$\frac{196.97 \text{ g}}{1 \text{ mol}} = 19.7 \text{ g Au}$

26) $C_{10}H_{12}O_4S + 12O_2 \longrightarrow$

$5CO_2 + SO_2 + 6H_2O$

30) $\overset{-2}{H_2Se} + 4\overset{+1}{O_2F_2} \rightarrow$

$\overset{+6}{SeF_6} + 2HF + 4O_2$

33) $1L \times \frac{.1 \text{ mol}}{L} NaCl \times \frac{1 \text{ mol } Cl^-}{\text{mol}} = .1 \text{ mol } Cl^-$

$1L \times \frac{.1 \text{ mol}}{L} CaCl_2 \times \frac{2 \text{ mol } Cl^-}{1 \text{ mol}} = .2 \text{ mol } Cl^-$

$Cl^- + Ag^+ \Rightarrow AgCl$

$.3 \text{ mol} \quad .3 \text{ mol}$

34) $AlF_6^{3-} + 3e^- \longrightarrow \overset{0}{Al} + 6F^-$

$\overset{+3}{}$

35) $15\,min \times \frac{60s}{1\,min} \times \frac{10C}{5} \times \frac{1\,mol\,e^-}{96500C}$

$\times \frac{1\,mol\,Al^{3+}}{3\,mole^-} \times \frac{27g}{mol\,Al}$

45) $HCN \rightleftharpoons H^+ + CN^-$

$.05 - x \qquad x \qquad x$

$5 \times 10^{-10} = \frac{x^2}{.05}$

$x = 5 \times 10^{-6}$

46) $Cu^{2+} + 4\,NH_3 \rightarrow Cu(NH_3)_4^{2+}$

47) $62.2g\,HF \times \frac{1mol}{178.49} = \frac{.348\,mol}{.348} = 1$

$37.4g\,Cl \times \frac{mol}{35.45} = \frac{1.055\,mol}{.348} = 3$

$HFCl_3$

48) 50%
25%
12.5%

$\frac{24}{3} = 8$

53. $W + X \rightarrow Y + Z$

1.2	1.6	0	0
1.0	1.4	.2	.2

55. $10\,HI + 2\,KMnO_4 + 3\,H_2SO_4 \rightarrow$

$5\,I_2 + 2\,MnSO_4 + K_2SO_4 + 8$

$$2.5\,mol\,I_2 \times \frac{10\,mol\,HI}{5\,mol\,I} = 5\,mol\,HI$$

57. 2.46

$$\frac{-.80}{1.66} = Al \rightarrow 3e^- + Al^{3+}$$

$$-1.66 = Al^{3+} + 3e^- \rightarrow Al$$

59. $40\,mL\ KOH \times \frac{.25\,mol}{mL} = 10\,mmol$

$60\,mL\ Ba(OH)_2 \times \frac{2(.15)\,mol}{mL} = 18\,mmol$

$$OH^- = \frac{28\,mmol}{100\,mL} = .28M$$

60) $NH_4NO_3 \rightarrow N_2O_{(g)} + 2H_2O_{(g)}$

.03

0   .03   .06

$$P = \frac{(.09 mol)(.0821 \frac{L\,atm}{mol\,K})(400 K)}{1 L}$$

$= 3 atm$

61) $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O_g$ -1323

$2H_2O_g \rightarrow 2H_2O_l$ -88

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + H_2O_l$ -1411 kJ

67) $Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$

2x   x

$4x^3 = (2x)^2(x) = 8 \times 10^{-12}$