1994 Advanced Placement Chemistry Exam
Part I: Multiple Choice

Note: For all questions involving solutions and/or chemical equations, assume that the system is in pure water and at room temperature unless otherwise stated.

Directions: Each set of lettered choices below refers to the numbered questions or 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

(A) Heisenberg uncertainty principle
(B) Pauli exclusion principle
(C) Hund's rule (principle of maximum multiplicity)
(D) Shielding effect
(E) Wave nature of matter

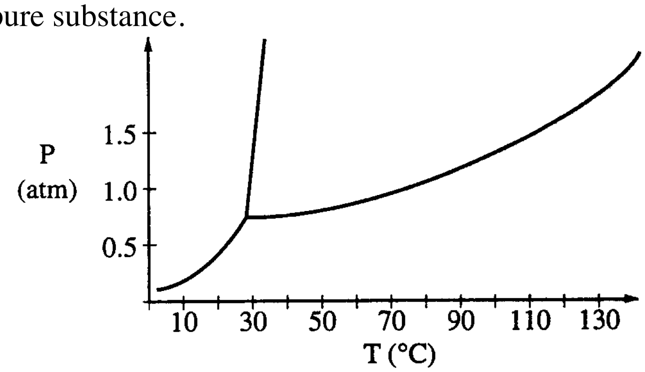
1. Can be used to predict that a gaseous carbon atom in its ground state is paramagnetic

2. Explains the experimental phenomenon of electron diffraction

3. Indicates that an atomic orbital can hold no more than two electrons

4. Predicts that it is impossible to determine simultaneously the exact position and the exact velocity of an electron

Questions 5–7 refer to the phase diagram below of a pure substance.



(A) Sublimation
(B) Condensation
(C) Solvation
(D) Fusion
(E) Freezing

5. If the temperature increases from 10˚C to 60˚C at a constant pressure of 0.4 atmosphere, which of the processes occurs?

6. If the temperature decreases from 110˚C to 40˚C at a constant pressure of 1.1 atmospheres, which of the processes occurs?

7. If the pressure Increases from 0.5 to 1.5 atmospheres at a constant temperature of 50˚C, which of the processes occurs?

Questions 8–10 refer to the following diatomic species.

(A) Li_2
(B) B_2
(C) N_2
(D) O_2
(E) F_2

8. Has the largest bond–dissociation energy

9. Has a bond order of 2

10. Contains 1 sigma (*s*) and 2 pi (π) bonds

Questions 11–13

(A) Pb
(B) Ca
(C) Zn
(D) As
(E) Na

11. Utilized as a coating to protect Fe from corrosion

12. Is added to silicon to enhance its properties as a semiconductor

13. Utilized as a shield from sources of radiation

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.

14. Which of the following is lower for a 1.0–molar aqueous solution of any solute than it is for pure water?

(A) pH
(B) Vapor pressure
(C) Freezing point
(D) Electrical conductivity
(E) Absorption of visible light

15. In a molecule in which the central atom exhibits sp^3d^2 hybrid orbitals, the electron pairs are directed toward the corners of

(A) a tetrahedron
(B) a square-based pyramid
(C) a trigonal bipyramid
(D) a square
(E) an octahedron

16. Commercial vinegar was titrated with NaOH solution to determine the content of acetic acid, $HC_2H_3O_2$. For 20.0 milliliters of the vinegar, 26.7 milliliters of 0.600–molar NaOH solution was required. What was the concentration of acetic acid in the vinegar if no other acid was present?

(A) 1.60 M (B) 0.800 M (C) 0.600 M
(D) 0.450 M (E) 0.200 M

17. Relatively slow rates of chemical reaction are associated with which of the following?

(A) The presence of a catalyst
(B) High temperature
(C) High concentration of reactants
(D) Strong bonds in reactant molecules
(E) Low activation energy

18. $2\ H_2O + 4\ MnO_4^- + 3\ ClO_2^- \rightarrow 4\ MnO_2 + 3\ ClO_4^- + 4\ OH^-$

Which species acts as an oxidizing agent in the reaction represented above?

(A) H_2O (B) ClO_4^- (C) ClO_2^-
(D) MnO_2 (E) MnO_4^-

19. In which of the following compounds is the mass ratio of chromium to oxygen closest to 1.62 to 1.00 ?

(A) CrO_3 (B) CrO_2 (C) CrO
(D) Cr_2O (E) Cr_2O_3

20. $\ldots\ Ag^+ + \ldots\ AsH_{3(g)} + \ldots\ OH^- \rightarrow \ldots\ Ag_{(s)} + \ldots\ H_3AsO_{3(aq)} + \ldots\ H_2O$

When the equation above is balanced with lowest whole–number coefficients, the coefficient for OH^- is

(A) 2 (B) 4 (C) 5
(D) 6 (E) 7

21. Correct statements about alpha particles include which of the following?

I. They have a mass number of 4 and a charge of +2.

II. They are more penetrating than beta particles.

III. They are helium nuclei.

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

$$HSO_4^- + H_2O \surd H_3O+ + SO_4^{2-}$$

22. In the equilibrium represented above, the species that act as bases include which of the following?

I. HSO_4^- II. H_2O III. SO_4^{2-}

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

Step 1: $Ce^{4+} + Mn^{2+} \rightarrow Ce^{3+} + Mn^{3+}$
Step 2: $Ce^{4+} + Mn^{3+} \rightarrow Ce^{3+} + Mn^{4+}$
Step 3: $Mn^{4+} + Tl^{+} \rightarrow Tl^{3+} + Mn^{2+}$

23. The proposed steps for a catalyzed reaction between Ce^{4+} and Tl^{+} are represented above. The products of the overall catalyzed reaction are

(A) Ce^{4+} and Tl^{+} (B) Ce^{3+} and Tl^{3+}
(C) Ce^{3+} and Mn^{3+} (D) Ce^{3+} and Mn^{4+}
(E) Tl^{3+} and Mn^{2+}

24. A sample of 0.0100 mole of oxygen gas is confined at 37˚C and 0.216 atmosphere. What would be the pressure of this sample at 15˚C and the same volume?

(A) 0.0876 atm (B) 0.175 atm
(C) 0.201 atm (D) 0.233 atm
(E) 0.533 atm

25. $H_2(g) + {}^1/_2\, O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -286$ kJ
$2\, Na(s) + {}^1/_2\, O_2(g) \rightarrow Na_2O(s)$ $\Delta H° = -414$ kJ
$Na(s) + {}^1/_2\, O_2(g) + 2\, H_2(g) \rightarrow NaOH(s)$
$\Delta H° = -425$ kJ

Based on the information above, what is the standard enthalpy change for the following reaction?

$$Na_2O(s) + H_2O(l) \rightarrow 2\, NaOH(s)$$

(A) –1,125 kJ (B) –978 kJ
(C) –722 kJ (D) –150 kJ
(E) +275 kJ

26. Which of the following actions would be likely to change the boiling point of a sample of a pure liquid in an open container?

I. Placing it in a smaller container

II. Increasing the number of moles of the liquid in the container

III. Moving the container and liquid to a higher altitude

(A) I only (B) II only

(C) III only (D) II and III only

(E) I, II, and III

27. Which of the following sets of quantum numbers (n, l, m_l, m_s) best describes the valence electron of highest energy in a ground–state gallium atom (atomic number 31) ?

(A) $4, 0, 0, \frac{1}{2}$ (B) $4, 0, 1, \frac{1}{2}$

(C) $4, 1, 1, \frac{1}{2}$ (D) $4, 1, 2, \frac{1}{2}$

(D) $4, 2, 0, \frac{1}{2}$

28. Given that a solution is 5 percent sucrose by mass, what additional information is necessary to calculate the molarity of the solution?

I. The density of water

II. The density of the solution

III. The molar mass of sucrose

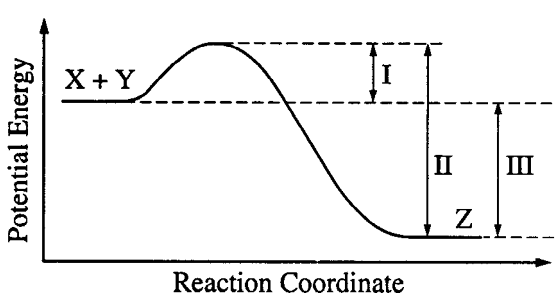
(A) I only (B) II only (C) III only

(D) I and III (E) II and III

29. When an aqueous solution of NaOH is added to an aqueous solution of potassium dichromate, $K_2Cr_2O_7$, the dichromate ion is converted to

(A) CrO_4^{2-} (B) CrO_2 (C) Cr^{3+}

(D) $Cr_2O_{3(s)}$ (E) $Cr(OH)_{3(s)}$



30. The energy diagram for the reaction X + Y → Z is shown above. The addition of a catalyst to this reaction would cause a change in which of the indicated energy differences?

(A) I only (B) II only

(C) III only (D) I and II only

(E) I, II, and III

31. $H_2C_2O_4 + 2\ H_2O \rightleftharpoons 2\ H_3O^+ + C_2O_4^{2-}$

Oxalic acid, $H_2C_2O_4$, is a diprotic acid with $K_1 = 5.36\times10^{-2}$ and $K_2 = 5.3\times10^{-5}$. For the reaction above, what is the equilibrium constant?

(A) 5.36×10^{-2} (B) 5.3×10^{-5}

(C) 2.8×10^{-6} (D) 1.9×10^{-10}

(E) 1.9×10^{-13}

32. CH_3CH_2OH boils at 78˚C and CH_3OCH_3 boils at –24˚C, although both compounds have the same composition. This difference in boiling points may be attributed to a difference in

(A) molecular mass (B) density

(C) specific heat (D) hydrogen bonding

(E) heat of combustion

33. A hydrocarbon gas with an empirical formula CH_2 has a density of 1.88 grams per liter at 0˚C and 1.00 atmosphere. A possible formula for the hydrocarbon is

(A) CH_2 (B) C_2H_4 (C) C_3H_6

(D) C_4H_8 (E) C_5H_{10}

34. X. $CH_3–CH_2–CH_2–CH_2–CH_3$

Y. $CH_3–CH_2–CH_2–CH_2–OH$

Z. $HO–CH_2–CH_2–CH_2–OH$

Based on concepts of polarity and hydrogen bonding, which of the following sequences correctly lists the compounds above in the order of their increasing solubility in water?

(A) Z < Y < X (B) Y < Z < X

(C) Y < X < Z (D) X < Z < Y

(E) X < Y < Z

35. For which of the following processes would ΔS have a negative value?

I. $2\ Fe_2O_{3(s)} \rightarrow 4\ Fe_{(s)} + 3\ O_{2(g)}$

II. $Mg^{2+} + 2\ OH^- \rightarrow Mg(OH)_{2(s)}$

III. $H_{2(g)} + C_2H_{4(g)} \rightarrow C_2H_{6(g)}$

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

36. $Zn_{(s)} + Cu^{2+} \surd Zn^{2+} + Cu_{(s)}$

An electrolytic cell based on the reaction represented above was constructed from zinc and copper half–cells. The observed voltage was found to be 1.00 volt instead of the standard cell potential, $E°$, of 1.10 volts. Which of the following could correctly account for this observation?

(A) The copper electrode was larger than the zinc electrode.
(B) The Zn^{2+} electrolyte was $Zn(NO_3)_2$, while the Cu^{2+} electrolyte was $CuSO_4$.
(C) The Zn^{2+} solution was more concentrated than the Cu^{2+} solution.
(D) The solutions in the half–cells had different volumes.
(E) The salt bridge contained KCl as the electrolyte.

37. A sample of 3.30 grams of an ideal gas at 150.0˚C and 1.25 atmospheres pressure has a volume of 2.00 liters. What is the molar mass of the gas? The gas constant, R, is 0.0821 (L·atm)/(mol·K).

(A) 0.0218 gram/mole (B) 16.2 grams/mole
(C) 37.0 grams/mole (D) 45.8 grams/mole
(E) 71.6 grams/mole

38. Concentrations of colored substances are commonly measured by means of a spectrophotometer. Which of the following would ensure that correct values are obtained for the measured absorbance?

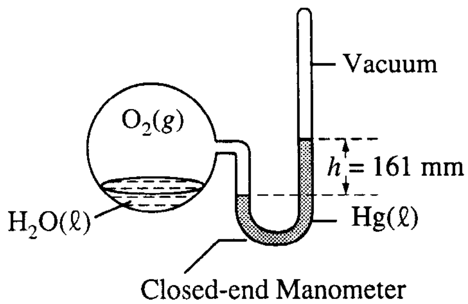
I. There must be enough sample in the tube to cover the entire light path.
II. The instrument must be periodically reset using a standard.
III. The solution must be saturated.

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

39. Samples of F_2 gas and Xe gas are mixed in a container of fixed volume. The initial partial pressure of the F_2 gas is 8.0 atmospheres and that of the Xe gas is 1.7 atmospheres. When all

of the Xe gas reacted, forming a solid compound, the pressure of the unreacted F_2 gas was 4.6 atmospheres. The temperature remained constant. What is the formula of the compound?

(A) XeF (B) XeF_3 (C) XeF_4
(D) XeF_6 (E) XeF_8



40. The system shown above is at equilibrium at 28˚C. At this temperature, the vapor pressure of water is 28 millimeters of mercury. The partial pressure of $O_{2(g)}$ in the system is

(A) 28 mm Hg (B) 56 mm Hg
(C) 133 mm Hg (D) 161 mm Hg
(E) 189 mm Hg

41. A strip of metallic scandium, Sc, is placed in a beaker containing concentrated nitric acid. A brown gas rapidly forms, the scandium disappears, and the resulting liquid is brown–yellow but becomes colorless when warmed. These observations best support which of the following statements?

(A) Nitric acid is a strong acid.
(B) In solution scandium nitrate is yellow and scandium chloride is colorless.
(C) Nitric acid reacts with metals to form hydrogen.
(D) Scandium reacts with nitric acid to form a brown gas.
(E) Scandium and nitric acid react in mole proportions of 1 to 3.

42.

Mass of an empty container	3.0 grams
Mass of the container plus the solid sample	25.0 grams
Volume of the solid sample	11.0 cm^3

The data above were gathered in order to determine the density of an unknown solid. The density of the sample should be reported as

(A) 0.5 g/cm^3 (B) 0.50 g/cm^3
(C) 2.0 g/cm^3 (D) 2.00 g/cm^3
(E) 2.27 g/cm^3

43. Which of the following pairs of compounds are isomers?

(A) $CH_3-CH_2-CH_2-CH_3$ and $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$

(B) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$ and $CH-\underset{\displaystyle CH_3}{\underset{|}{C}}=CH_2$

(C) CH_3-O-CH_3 and $CH_3-\overset{\displaystyle O}{\overset{\|}{C}}-CH_3$

(D) CH_3-OH and CH_3-CH_2-OH

(E) CH_4 and $CH_2=CH_2$

45. A sample of an ideal gas is cooled from 50.0˚C to 25.0˚C in a sealed container of constant volume. Which of the following values for the gas will decrease?

I. The average molecular mass of the gas

II. The average distance between the molecules

III. The average speed of the molecules

(A) I only (B) II only (C) III only

(D) I and III (E) II and III

46. Which of the following solids dissolves in water to form a colorless solution?

(A) $CrCl_3$ (B) $FeCl_3$ (C) $CoCl_2$

(D) $CuCl_2$ (E) $ZnCl_2$

47. Which of the following has the lowest conductivity?

(A) 0.1 *M* $CuSO_4$ (B) 0.1 *M* KOH

(C) 0.1 *M* $BaCl_2$, (D) 0.1 *M* HF

(E) 0.1 *M* HNO_3

48. $PCl_{3(g)} + Cl_{2(g)} = PCl_{5(g)}$ + energy

Some PCl_3 and Cl_2 are mixed in a container at 200˚C and the system reaches equilibrium according to the equation above. Which of the following causes an increase in the number of moles of PCl_5 present at equilibrium?

I. Decreasing the volume of the container

II. Raising the temperature

III. Adding a mole of He gas at constant volume

(A) I only (B) II only

(C) I and III only (D) II and III only

(E) I, II, and Ill

49. The isomerization of cyclopropane to propylene is a first–order process with a half–life of 19 minutes at 500˚C. The time it takes for the partial pressure of cyclopropane to decrease from 1.0 atmosphere to 0.125 atmosphere at 500˚C is closest to

(A) 38 minutes (B) 57 minutes
(C) 76 minutes (D) 152 minutes
(E) 190 minutes

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

(A) H_3PO_4 (B) HNO_3 (C) H_2CO_3
(D) H_3BO_3 (E) H_2SO_3

51. $4\ HCl_{(g)} + O_{2(g)} \rightarrow 2\ Cl_{2(g)} + 2\ H_2O_{(g)}$

Equal numbers of moles of HCl and O_2 in **a closed** system are allowed to reach equilibrium as represented by the equation above Which of the following must be true at equilibrium?

I. [HCl] must he less than [Cl_2].

II. [O_2] must be greater than [HCl].

III. [Cl_2] must equal [H_2O].

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

52. When dilute nitric acid was added to a solution of one of the following chemicals, a gas was evolved. This gas turned a drop of limewater, $Ca(OH)_2$, cloudy, due to the formation of a white precipitate. The chemical was

(A) household ammonia, NH_3
(B) baking soda, $NaHCO_3$
(C) table salt, NaCl
(D) Epsom salts, $MgSO_4{\cdot}7H_2O$
(E) bleach, 5% NaOCl

53. If 87 grams of K_2SO_4 (molar mass 174 grams) is dissolved in enough water to make 250 milliliters of solution, what are the concentrations of the potassium and the sulfate ions?

	$[K^+]$	$[SO_4^{2-}]$
(A)	0.020 *M*	0.020 *M*
(B)	1.0 *M*	2.0 *M*
(C)	2.0 *M*	1 .0 *M*
(D)	2.0 *M*	2.0 *M*
(E)	4.0 *M*	2.0 *M*

54. All of the following statements concerning the characteristics of the halogens are true EXCEPT:

(A) The first ionization energies (potentials) decrease as the atomic numbers of the halogens increase.

(B) Fluorine is the best oxidizing agent.

(C) Fluorine atoms have the smallest radii.

(D) Iodine liberates free bromine from a solution of bromide ion.

(E) Fluorine is the most electronegative of the halogens.

55. What volume of 0.150–molar HCl is required to neutralize 25.0 milliliters of 0.120–molar $Ba(OH)_2$?

(A) 20.0 mL (B) 30.0 mL (C) 40.0 mL
(D) 60.0 mL (E) 80.0 mL

56. It is suggested that SO_2 (molar mass = 64.1 grams), which contributes to acid rain, could be removed from a stream of waste gases by bubbling the gases through 0.25–molar KOH, thereby producing K_2SO_3. What is the maximum mass of SO_2 that could be removed by 1,000. liters of the KOH solution?

(A) 4.0 kg (B) 8.0 kg (C) 16 kg
(D) 20. kg (E) 40. kg

57. Molecules that have planar configurations include which of the following?

I. BCl_3 II. $CHCl_3$ III. NCl_3

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

58. $N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3(g)$

The reaction indicated above is thermodynamically spontaneous at 298 K, but becomes nonspontaneous at higher temperatures. Which of the following is true at 298 K?

(A) ΔG, ΔH, and ΔS are all positive.

(B) ΔG, ΔH. and ΔS are all negative.

(C) ΔG and ΔH are negative, but ΔS is positive.

(D) ΔG and ΔS are negative, but ΔH is positive.

(E) ΔG and ΔH are positive, but ΔS is negative.

59. When a 1.00–gram sample of limestone was dissolved in acid, 0.38 gram of CO_2 was generated. If the rock contained no carbonate other than $CaCO_3$, what was the percent of $CaCO_3$ by mass in the limestone?

(A) 17% (B) 51% (C) 64%
(D) 86% (E) 100%

60. $I_2(g) + 3\,Cl_2(g) \rightarrow 2\,ICl_3(g)$

According to the data in the table below, what is the value of ΔH° for the reaction represented above?

Bond	Average Bond Energy (kilojoules/mole)
I–I	149
Cl–Cl	239
I–Cl	208

(A) –860 kJ (B) –382 kJ
(C) +180 kJ (D) +450 kJ
(E) +1,248 kJ

61. A 1–molar solution of which of the following salts has the highest pH?

(A) $NaNO_3$ (B) Na_2CO_3 (C) NH_4Cl
(D) $NaHSO_4$ (E) Na_2SO_4

62. The electron–dot structure (Lewis structure) for which of the following molecules would have two unshared pairs of electrons on the central atom?

(A) H_2S (B) NH_3 (C) CH_4
(D) HCN (E) CO_2

63. What is the maximum mass of copper that could be plated out by electrolyzing aqueous $CuCl_2$ for 16.0 hours at a constant current of 3.00 amperes? (1 faraday = 96,500 coulombs)

(A) 28 grams (B) 57 grams (C) 64 grams
(D) 114 grams (E) 128 grams

64. At 25˚C, a sample of NH_3 (molar mass 17 grams) effuses at the rate of 0.050 mole per minute. Under the same conditions, which of the following gases effuses at approximately one–half that rate?

(A) O_2 (molar mass 32 grams)

(B) He (molar mass 4.0 grams)

(C) CO_2 (molar mass 44 grams)

(D) Cl_2 (molar mass 71 grams)

(E) CH_4 (molar mass 16 grams)

65. Barium sulfate is LEAST soluble in a 0.01–molar solution of which of the following?

(A) $Al_2(SO_4)_3$
(B) $(NH_4)_2SO_4$
(C) Na_2SO_4
(D) NH_3
(E) $BaCl_2$

66. What is the pH of a 1.0×10^{-2} molar solution of HCN? (For HCN, $K_a = 4.0\times10^{-10}$.)

(A) 10
(B) Between 7 and 10
(C) 7
(D) Between 1 and 7
(E) 4

67. Substances X and Y that were in a solution were separated in the laboratory using the technique of fractional crystallization. This fractional crystallization is possible because substances X and Y have different

(A) boiling points
(B) melting points
(C) densities
(D) crystal colors
(E) solubilities

68. Which of the following molecules has a dipole moment of zero?

(A) C_6H_6 (benzene)
(B) NO
(C) SO_2
(D) NH_3
(E) H_2S

69. Correct procedures for a titration include which of the following?

I. Draining a pipet by touching the tip to the side of the container used for the titration
II. Rinsing the buret with distilled water just before filling it with the liquid to be titrated
III. Swirling the solution frequently during the titration

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

70. To determine the molar mass of a solid monoprotic acid, a student titrated a weighed sample of the acid with standardized aqueous NaOH. Which of the following could explain why the student obtained a molar mass that was too <u>large</u>?

I. Failure to rinse all acid from the weighing paper into the titration vessel
II. Addition of more water than was needed 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) II and III only
(E) I, II, and III

71. $\ldots Fe(OH)_2 + \ldots O_2 + \ldots H_2O \rightarrow \ldots Fe(OH)_3$

If 1 mole of O_2 oxidizes $Fe(OH)_2$ according to the reaction represented above, how many moles of $Fe(OH)_3$ can be formed?

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

72. The nuclide ${}^{249}_{96}\text{Cm}$ is radioactive and decays by the loss of one beta (β^-) particle. The product nuclide is

(A) ${}^{245}_{94}\text{Pu}$ (B) ${}^{245}_{95}\text{Am}$ (C) ${}^{248}_{96}\text{Cm}$

(D) ${}^{250}_{96}\text{Cm}$ (E) ${}^{249}_{97}\text{Bk}$

73. $2\ SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\ SO_{3(g)}$

When 0.40 mole of SO_2 and 0.60 mole of O_2 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 SO_3. Based on these results, the equilibrium constant, *Kc,* for the reaction is

(A) 20. (B) 10. (C) 6.7

(D) 2.0 (E) 1.2

74. A solution of calcium hypochlorite, a common additive to swimming–pool water, is

(A) basic because of the hydrolysis of the OCl^- ion

(B) basic because $Ca(OH)_2$ is a weak and insoluble base

(C) neutral if the concentration is kept below 0.1 molar

(D) acidic because of the hydrolysis of the Ca^{2+} ions

(E) acidic because the acid HOCl is formed

75. A direct–current power supply of low voltage (less than 10 volts) has lost the markings that indicate which output terminal is positive and which is negative. A chemist suggests that the power supply terminals be connected to a pair of platinum electrodes that dip into 0.1–molar KI solution. Which of the following correctly identifies the polarities of the power supply terminals?

(A) A gas will be evolved only at the positive electrode.

(B) A gas will be evolved only at the negative electrode.

(C) A brown color will appear in the solution near the negative electrode.

(D) A metal will be deposited on the positive electrode.

(E) None of the methods above will identify the polarities of the power supply terminals.

1994 AP Chemistry Exam – Multiple Choice Answers

Question #	Answer	% Correct	Question #	Answer	% Correct	Question #	Answer	% Correct
1	C	32	26	C	61	51	D	29
2	E	38	27	C	48	52	B	29
3	B	44	28	E	58	53	E	55
4	A	82	29	A	36	54	D	43
5	A	73	30	D	55	55	C	35
6	B	74	31	C	39	56	B	35
7	B	66	32	D	77	57	A	46
8	C	21	33	C	52	58	B	29
9	D	47	34	E	39	59	D	29
10	C	57	35	D	54	60	B	47
11	C	52	36	C	46	61	B	21
12	D	21	37	D	81	62	A	64
13	A	78	38	C	41	63	B	24
14	C	46	39	C	38	64	D	23
15	E	50	40	C	67	65	A	21
16	B	69	41	D	58	66	D	64
17	D	82	42	D	39	67	E	25
18	E	62	43	A	55	68	A	41
19	B	83	44	E	31	69	C	36
20	D	58	45	C	44	70	A	15
21	D	58	46	E	46	71	C	33
22	E	62	47	D	38	72	E	53
23	B	71	48	A	35	73	A	24
24	C	76	49	B	49	74	A	34
25	D	63	50	E	58	75	B	16

Average % correct = 47.75 ± 17.81

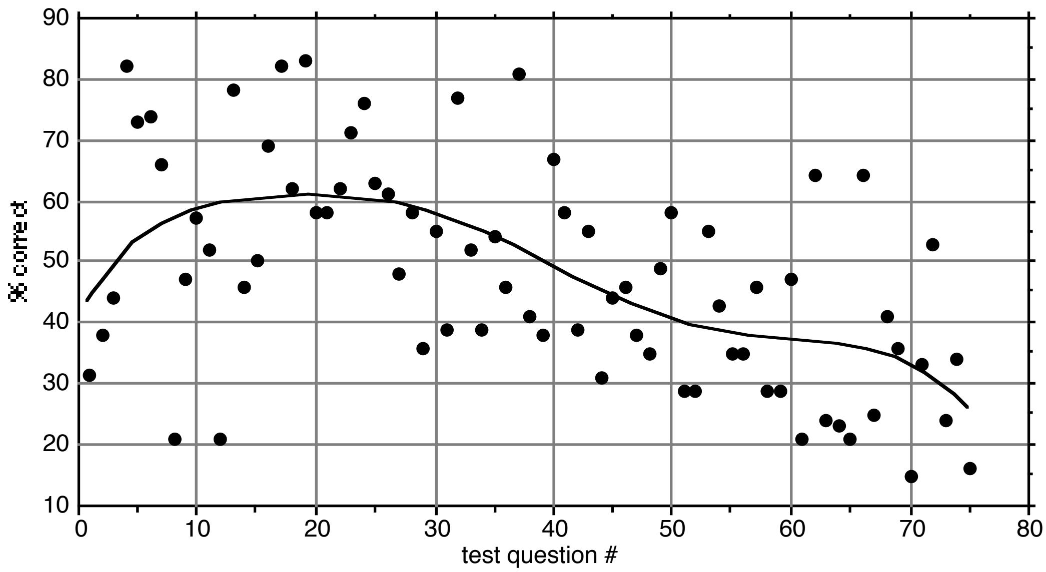
VERY EASY (80–100% correct), 5.3%
4 17 19 37
EASY (60–79% correct), 20.0%
5 6 7 13 16 18 22 23 24 25 26 32 40 62 66
MEDIUM DIFFICULTY (40–59% correct), 34.7%
3 9 11 14 15 20 21 27 28 30 33 35 36 38 41
43 45 46 49 50 53 54 57 60 68 72
HARD (20–39% correct), 37.3%
1 2 8 10 12 29 31 34 39 42 44 47 48 51 52
55 56 58 59 61 63 64 65 67 69 71 73 74
VERY HARD (0–19% correct), 2.7%
70 75
– – – – – – – – – – – – – –

[$^1/_4$ of wrong answers subtracted from # correct]

Multiple–Choice Score	AP Grade (%)					Total (%)
	1	**2**	**3**	**4**	**5**	

48–75	0.0	0.0	0.6	15.9	83.5	12.4
37–47	0.0	0.3	21.3	64.1	14.4	18.1
24–36	0.1	15.4	70.5	13.9	0.1	31.1
13–23	11.1	71.1	17.8	0.0	0.0	24.4
0–12	79.3	20.5	0.2	0.0	0.0	13.9
Total	13.7	25.1	30.3	17.9	13.0	100

1994 AP Chemistry Exam



REVISED QUANTITATIVE ITEMS FROM THE 1994 CHEMISTRY EXAM

There were a total of 20 quantitative questions in the multiple-choice section of the 1994 AP Chemistry Exam. Below are 10 quantitative questions from this group rewritten to conform to the new format being introduced in 1996, in which calculators will not be allowed for the multiple-choice questions. (The capital "R" following the question number indicates that it is a Revised question.) The remaining quantitative questions from the 1994 exam are those for which students would not typically need a calculator, and therefore represent quantitative questions that would appear exactly as they are now on the new format of the exam.

16R. Commercial vinegar was titrated with NaOH solution to determine the content of acetic acid, $HC_2H_3O_2$. For 20.0 milliliters of the vinegar, 32.0 milliliters of 0.500–molar NaOH solution was required. What was the concentration of acetic acid in the vinegar if no other acid was present?

(A) 1.60 M (B) 0.800 M (C) 0.640 M
(D) 0.600 M (E) 0.400 M

19R. In which of the following compounds is the mass ratio of chromium to oxygen closest to 1.6 to 1.0?

(A) CrO_3 (B) CrO_2 (C) CrO
(D) Cr_2O (E) Cr_2O_3

24R. A sample of 0.0100 mole of oxygen gas is confined at 127˚C and 0.80 atmosphere. What would be the pressure of this sample at 27˚C and the same volume?

(A) 0.10 atm (B) 0.20 atm
(C) 0.60 atm (D) 0.80 atm
(E) 1.1 atm

25R. $H_{2(g)} + {}^1/_2\, O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H^\circ = x$

$2\, Na_{(s)} + {}^1/_2\, O_{2(g)} \rightarrow Na_2O_{(s)}$ $\Delta H^\circ = y$

$Na_{(s)} + {}^1/_2\, O_{2(g)} + 2\, H_{2(g)} \rightarrow NaOH_{(s)}$ $\Delta H^\circ = z$

Based on the information above, what is the standard enthalpy change for the following reaction?

$$Na_2O_{(s)} + H_2O_{(l)} \rightarrow 2\, NaOH_{(s)}$$

(A) x + y + z (B) x + y – z
(C) x + y – 2z (D) 2z – x – y
(E) z – x – y

31R. $H_2C_2O_4 + 2\, H_2O \rightleftharpoons 2\, H_3O^+ + C_2O_4^{2-}$

Oxalic acid, $H_2C_2O_4$, is a diprotic acid with $K_1 = 5\times10^{-2}$ and $K_2 = 5\times10^{-5}$. Which of the following is equal to the equilibrium constant for the reaction represented above?

(A) 5×10^{-2} (B) 5×10^{-5}
(C) 2.5×10^{-6} (D) 5×10^{-7}
(E) 2.5×10^{-8}

37R. A sample of 3.0 grams of an ideal gas at 127˚C and 1.0 atmosphere pressure has a volume of 1.50 liters. Which of the following expressions is correct for the molar mass of the gas? The gas constant, R, is 0.08 (L·atm)/(mol·K).

(A) $\dfrac{(0.08)(400)}{(3.0)(1.0)(1.5)}$ (B) $\dfrac{(1.0)(1.5)}{(3.0)(0.08)(400)}$

(C) $\dfrac{(0.08)(1.0)(1.5)}{(3.0)(400)}$ (D) $\dfrac{(3.0)(0.08)(400)}{(1.0)(1.5)}$

(E) $\dfrac{(3.0)(0.08)(1.5)}{(1.0)(400)}$

59R. When a 1.25–gram sample of limestone was dissolved in acid, 0.44 gram of CO_2 was generated. If the rock contained no carbonate other than $CaCO_3$, what was the percent of $CaCO_3$ by mass in the limestone?

(A) 35% (B) 44% (C) 67%
(D) 80% (E) 100%

60R. $I_{2(g)} + 3\, Cl_{2(g)} \rightarrow 2\, ICl_{3(g)}$

According to the data in the table below, what is the value of ΔH° for the reaction represented above?

Bond	Average Bond Energy (kilojoules/mole)
I–I	150
Cl–Cl	240
I–Cl	210

(A) –870 kJ
(B) –390 kJ
(C) +180 kJ
(D) +450 kJ
(E) +1,260 kJ

63R. Which of the following expressions is correct for the maximum mass of copper, in grams, that could be plated out by electrolyzing aqueous $CuCl_2$ for 16.0 hours at a constant current of 3.0 amperes? (1 faraday = 96,500 coulombs)

(A) $\dfrac{(16)(3{,}600)(3.0)(63.55)(2)}{(96{,}500)}$

(B) $\dfrac{(16)(3{,}600)(3.0)(63.55)}{(96{,}500)(2)}$

(C) $\dfrac{(16)(3{,}600)(3.0)(63.55)}{(96{,}500)}$

(D) $\dfrac{(16)(60)(3.0)(96{,}500)(2)}{(63.55)}$

(E) $\dfrac{(16)(60)(3.0)(96{,}500)}{(63.55)(2)}$

73R. $2\ SO_{2(g)} + O_{2(g)} \surd\ 2\ SO_{3(g)}$

When 0.40 mole of SO_2 and 0.60 mole of O_2 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 SO_3. Based on these results, the equilibrium constant, *Kc,* for the reaction is

(A) $\dfrac{(0.30)^2}{(0.45)(0.10)^2}$

(B) $\dfrac{(0.30)^2}{(0.60)(0.40)^2}$

(C) $\dfrac{(2 \times 0.30)}{(0.45)(2 \times 0.10)}$

(D) $\dfrac{(0.30)}{(0.45)(0.10)}$

(E) $\dfrac{(0.30)}{(0.60)(0.40)}$

Answers to Revised Questions
16R. B
19R. B
24R. C
25R. D
31R. C
37R. D
59R. D
60R. B

63R. B
73R. A

Notes:

Notes: