

INDIANA SECTION of the AMERICAN CHEMICAL SOCIETY

High School Scholarship Exam

April 21, 2001



1. The exam contains 100 questions. You have 2 hours and 30 minutes to complete the exam.
2. Choose the single *best* answer for each question and darken the corresponding letter on your answer sheet. The score is based on the number of correct answers- there is no penalty for incorrect guesses.
3. Calculators are permitted, but stored programs and information are not allowed.
4. You may write on this exam. The exam does not need to be returned.
5. Use of significant digits and correct units may be considered in the choice of the best answer.
6. A periodic table and a sheet of selected formulas are also provided.

1. Which of the following is an element?
 - a) hydrochloric acid
 - b) copper
 - c) bronze
 - d) salt
 - e) limestone

2. Which of the following is a mixture?
 - a) calcium chloride
 - b) iron
 - c) bromine
 - d) ammonia (NH₃)
 - e) air

3. Which of the following is a chemical process?
 - a) combustion of methane
 - b) boiling of water
 - c) sublimation of carbon dioxide
 - d) cutting of diamond
 - e) dissolving sugar in water

4. Which of the following metric relationships is incorrect?
 - a) 1 microliter = 1 x 10⁻⁶ L
 - b) 1 megagram = 10⁶ g
 - c) 1 millimeter = 10³ m
 - d) 1 kilogram = 10³ g
 - e) 100 centimeters = 1 m

5. Express 784000000 in scientific notation
 - a) 784 x 10⁶
 - b) 7.84 x 10⁶
 - c) 7.84 x 10⁻⁶
 - d) 7.84 x 10⁸
 - e) 7.84 x 10⁻⁸

6. A titration was performed to find the concentration of hydrochloric acid with the following results:

Trial	Molarity
1	1.25 ± 0.01
2	1.24 ± 0.01
3	1.26 ± 0.01

The actual concentration of HCl was determined to be 1.00 M; the results of the titration are:

- a) both accurate and precise
- b) accurate but imprecise
- c) precise but inaccurate
- d) both imprecise and inaccurate
- e) accuracy and precision are impossible to determine with the available information

7. In March 1989, the Exxon Valdez ran aground and spilled 245,000 barrels of crude petroleum off the coast of Alaska. One barrel of petroleum is equal to 42.0 gallons; there are 3.784 L in one gallon. How many megaliters of petroleum were spilled?
- 38.9 ML
 - 3.89 ML
 - 389 ML
 - 2.72 ML
 - 3.89×10^{13} ML
8. The calibration points for the linear Reaumur scale are the usual melting point of ice and boiling point of water, which are assigned the values $0.0\text{ }^{\circ}\text{R}$ and $80.0\text{ }^{\circ}\text{R}$ respectively. The normal body temperature of humans is $98.6\text{ }^{\circ}\text{F}$. What is this temperature in $^{\circ}\text{R}$?
- 37.0
 - 28.0
 - 29.0
 - 29.6
 - 30.5
9. The density of aluminum is 2.70 g/cm^3 . What is the thickness (in mm) of a sheet of aluminum foil that is 12.0 inches by 8.0 inches and has a mass of 185 grams?
- 0.84
 - 0.32
 - 1.1
 - 0.11
 - 8.4
10. A freighter carrying a cargo of uranium hexafluoride sank in the English Channel in late August 1984. The cargo of uranium hexafluoride weighed $2.25 \times 10^8\text{ kg}$ and was contained in 30 drums, each having a volume of $1.62 \times 10^6\text{ L}$. What is the density (g/mL) of the uranium hexafluoride?
- 1.00
 - 4.16
 - 1.39
 - 46.3
 - 4.63
11. The state of matter for a substance that has both definite volume and definite shape is:
- solid state
 - liquid state
 - gaseous state
 - mixed state
 - elemental state
12. Which one of the following statements about atomic structure is false?
- The electrons occupy a very large volume compared to the nucleus.
 - Almost all of the mass of the atom is concentrated in the nucleus.
 - The protons and neutrons in the nucleus are very tightly packed.
 - The number of protons and neutrons is always the same in the neutral atom.

13. The element rhenium (Re) exists as two stable isotopes and 18 unstable isotopes. Rhenium-185 has in its nucleus:
- a) 75 protons, 75 neutrons
 - b) 75 protons, 185 neutrons
 - c) 110 protons, 75 neutrons
 - d) 75 protons, 110 neutrons
 - e) 185 protons, 110 neutrons
14. Which of the following has 45 neutrons, 35 protons, and 36 electrons?
- a) ${}_{80}^{116}\text{Hg}^+$
 - b) ${}_{45}^{80}\text{Rh}^-$
 - c) ${}_{35}^{45}\text{Br}^-$
 - d) ${}_{36}^{81}\text{Kr}$
 - e) ${}_{35}^{80}\text{Br}^-$
15. Which of the following are incorrectly paired?
- a) Na, alkali metal
 - b) Sn, transition metal
 - c) Mg, alkaline earth metal
 - d) Ar, noble gas
 - e) Br, halogen
16. All of the following are characteristic of metals except:
- a) good conductors of heat
 - b) malleable
 - c) ductile
 - d) tend to gain electrons in chemical reactions
 - e) often lustrous
17. The correct name for Au_3PO_4 is:
- a) gold (I) phosphate
 - b) gold (III) phosphate
 - c) gold phosphate
 - d) gold (I) phosphite
 - e) gold (III) phosphite
18. Which of the following ions has a 2- charge?
- a) perchlorate ion
 - b) dihydrogen phosphate ion
 - c) acetate ion
 - d) sulfite ion
 - e) bicarbonate ion
19. For which compound does 0.21 mole weigh approximately 10.6 g?
- a) $\text{C}_2\text{H}_4\text{O}$
 - b) CO_2
 - c) CH_3Cl
 - d) C_2H_6

- e) CH_4O
20. A given sample of sulfur chloride contains molecules of a single type, SCl_x , where x is some whole number. Given that 9.00×10^{22} molecules of SCl_x weigh 36.6 g, calculate x .
- a) 1
b) 2
c) 3
d) 4
e) 6
21. How many grams of potassium ions are needed to prepare 12.5 g of $\text{K}_2\text{Cr}_2\text{O}_7$?
- a) 3.32
b) 1.66
c) 3.91
d) 1.25
e) 4.04
22. What is the coefficient for water when the following equation is balanced?
 $\text{As}(\text{OH})_3 (\text{s}) + \text{H}_2\text{SO}_4 (\text{aq}) \rightarrow \text{As}_2(\text{SO}_4)_3 (\text{aq}) + \text{H}_2\text{O} (\text{l})$
- a) 1
b) 2
c) 3
d) 4
e) 6
23. Vitamin C contains elements C, H, and O. It is known to contain 40.9 % C and 4.58 % H by mass. The molar mass of Vitamin C has been found to be about 176 g. The molecular formula for Vitamin C is:
- a) $\text{C}_6\text{H}_8\text{O}_6$
b) $\text{C}_6\text{H}_4\text{O}_3$
c) $\text{C}_4\text{H}_6\text{O}_4$
d) $\text{C}_3\text{H}_4\text{O}_3$
e) $\text{C}_7\text{H}_{12}\text{O}_5$
24. What is the subscript of the iron in the formula for iron(III) carbonate?
- a) 0
b) 1
c) 2
d) 3
e) 4
25. The Claus reactions, shown below, are used to generate elemental sulfur from hydrogen sulfide:
$$2 \text{H}_2\text{S} + 3 \text{O}_2 \rightarrow 2 \text{SO}_2 + 2 \text{H}_2\text{O}$$
$$\text{SO}_2 + 2 \text{H}_2\text{S} \rightarrow 3 \text{S} + 2 \text{H}_2\text{O}$$

How many grams of sulfur can be produced from 48.0 grams of O_2 and excess H_2S ?
- a) 16.0 g
b) 32.1 g
c) 48.1 g

- d) 96.3 g
e) 144 g
26. A 15.0-g sample of lithium is reacted with 15.0 g of fluorine to form lithium fluoride:
 $2 \text{Li} + \text{F}_2 \rightarrow 2 \text{LiF}$. After the reaction is complete, what will be present?
- a) only 2.16 moles lithium fluoride
b) only 0.789 moles lithium fluoride
c) exactly 2.16 moles lithium fluoride and 0.395 moles fluorine
d) exactly 0.789 moles lithium fluoride and 1.37 moles lithium
e) exactly 0.789 moles lithium fluoride and 0.789 moles lithium
27. The reaction of 11.9 g of FeS_2 with excess oxygen produced 6.45 g of Fe_2O_3 :
 $4 \text{FeS}_2 + 11 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3 + 8 \text{SO}_2$. What is the percent yield?
- a) 54.2
b) 81.4
c) 75.3
d) 78.8
e) 18.6
28. Vitamin B_{12} , cyanocobalamin, is essential for human nutrition. This vitamin is concentrated in animal tissue but not in higher plants. People who abstain completely from animal products may develop anemia, so cyanocobalamin is used in vitamin supplements. Cyanocobalamin contains 4.38 % cobalt by mass. Calculate the molar mass of cyanocobalamin assuming that there is one cobalt ion per molecule.
- a) 58.9
b) 74.3
c) 135
d) 1350
e) 2280
29. How many grams of sodium chloride are needed to prepare 350. mL of a 0.250 M NaCl (aq) solution?
- a) 41.7
b) 5.11
c) 14.6
d) 87.5
e) 81.9
30. Which of the following aqueous solutions contains the greatest number of ions?
- a) 400.0 mL of 0.10 M NaCl
b) 300.0 mL of 0.10 M CaCl_2
c) 200.0 mL of 0.10 M FeCl_3
d) 200.0 mL of 0.10 M KBr
e) 800.0 mL of 0.10 M sucrose
31. A 51.24-g sample of $\text{Ba}(\text{OH})_2$ is dissolved in enough water to make 1.20 L of solution. How many milliliters of this solution must be diluted with water in order to make 1.00 L of 0.100 M $\text{Ba}(\text{OH})_2$?
- a) 4.00×10^2
b) 2.49×10^2
c) 1.20×10^3

- d) 6.14×10^2
 e) 3.33×10^2
32. What is the balanced net ionic equation for the reaction of lead(II) nitrate with sodium phosphate?
- a) $\text{Na}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) \rightarrow \text{NaNO}_3(\text{s})$
 b) $\text{Pb}^{2+}(\text{aq}) + \text{NO}_3^-(\text{aq}) \rightarrow \text{PbNO}_3(\text{s})$
 c) $2 \text{Pb}^{2+}(\text{aq}) + \text{PO}_4^{3-}(\text{aq}) \rightarrow \text{Pb}_2\text{PO}_4$
 d) $3 \text{Pb}^{2+}(\text{aq}) + 2 \text{PO}_4^{3-}(\text{aq}) \rightarrow \text{Pb}_3(\text{PO}_4)_2(\text{s})$
 e) there is no net ionic equation: all species are soluble spectator ions
33. The arsenic in a 1.50-g sample of pesticide was converted to AsO_4^{3-} by suitable chemical treatment. It was then titrated using a solution containing Ag^+ to form Ag_3AsO_4 as a precipitate. If it took 25.0 mL of 0.105 M Ag^+ to completely precipitate the AsO_4^{3-} as Ag_3AsO_4 , what is the mass percentage of arsenic in the pesticide?
- a) 4.37 %
 b) 6.56 %
 c) 8.10 %
 d) 13.1 %
 e) 19.7 %
34. A 100.0-mL sample of 0.50 M aqueous lead(II) nitrate is reacted with 100.0 mL of 0.50 M nickel(III) chloride. What is the concentration of chloride ion in the supernatant after the reaction?
- $$3 \text{Pb}(\text{NO}_3)_2(\text{aq}) + 2 \text{NiCl}_3(\text{aq}) \rightarrow 3 \text{PbCl}_2(\text{s}) + 2 \text{Ni}(\text{NO}_3)_3(\text{aq})$$
- a) 0.050 M
 b) 0.33 M
 c) 0.25 M
 d) 0.17 M
 e) 0.38 M
35. Which of the following is classified as a strong acid?
- a) HF
 b) KOH
 c) HClO_4
 d) HCN
 e) HBrO
36. Consider two organic molecules, ethanol and benzene. One dissolves in water and the other does not. Why?
- a) They have different molar masses
 b) One is ionic, the other is not
 c) One is an electrolyte, the other is not

- d) Ethanol contains a polar -O-H bond, and benzene does not
37. The following reactions:
- $$\text{Pb}^{2+} + 2 \text{I}^{-} \rightarrow \text{PbI}_2$$
- $$2 \text{Ce}^{4+} + 2 \text{I}^{-} \rightarrow \text{I}_2 + 2 \text{Ce}^{3+}$$
- $$\text{HC}_2\text{H}_3\text{O}_2 + \text{NH}_3 \rightarrow \text{NH}_4^{+} + \text{C}_2\text{H}_3\text{O}_2^{-}$$
- are examples of:
- acid-base reactions
 - unbalanced reactions
 - precipitation, acid-base, and redox reactions, respectively
 - redox, acid-base, and precipitation reactions, respectively
 - precipitation, redox, and acid-base reactions, respectively
38. A 1.000-g sample of a metal chloride, MCl_2 , is dissolved in water and treated with excess aqueous silver nitrate. The silver chloride that formed weighed 1.286 g. Calculate the molar mass of the metal M.
- 222.9
 - 76.00
 - 152.0
 - 304.0
 - 70.89
39. Malonic acid, $\text{H}_2\text{C}_3\text{H}_2\text{O}_4$, is a diprotic acid. A 1.50-g sample of malonic acid required 25.5 mL of an aqueous solution of KOH for complete reaction. What is the molarity of the KOH solution?
- 2.26
 - 1.13
 - 0.565
 - 1.77
 - 0.885
40. In the following reaction, which species is reduced?
- $$8 \text{NaI} + 5 \text{H}_2\text{SO}_4 \rightarrow 4 \text{I}_2 + \text{H}_2\text{S} + 4 \text{Na}_2\text{SO}_4 + 4 \text{H}_2\text{O}$$
- sodium
 - iodine
 - sulfur
 - hydrogen
 - oxygen
41. Given the following redox reaction in acidic media: $\text{Fe}^{2+} + \text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Fe}^{3+} + \text{Cr}^{3+}$
What is the correct coefficient of Fe^{2+} in the balanced reaction?
- 1
 - 4
 - 5
 - 6
 - 9
42. Consider three 1-L flasks at STP. Flask A contains NH_3 (g), flask B contains NO_2 (g), and flask C contains N_2 (g). Which contains the largest number of molecules?
- flask A
 - flask B

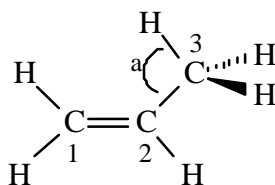
- c) flask C
d) all contain the same number of molecules
43. Consider 3 samples of gas at STP, NH_3 (g), NO_2 (g) and N_2 (g). In which sample do the molecules have the greatest average velocity?
a) NH_3
b) NO_2
c) N_2
d) they all have the same average velocity
44. Consider the reaction: 2NH_3 (g) + 3Cl_2 (g) \rightarrow N_2 (g) + 6HCl (g). If you react 5.00 atm of NH_3 with 5.00 atm of Cl_2 measured at the same temperature in a closed container, what is the ratio of pressures in the container ($P_{\text{final}}/P_{\text{initial}}$) if the reaction goes to completion?
a) 1.50
b) 1.33
c) 1.17
d) 1.00
e) 0.75
45. A certain gas has the composition 87.5 % N and 12.5 % H by mass. A 0.500-g sample of this gas has a volume of 318 mL at a pressure of 1.20 atm and a temperature of 298 K. What is the molecular formula of the gas?
a) NH_3
b) N_2H_2
c) NH_2
d) N_2H_4
e) N_3H_6
46. Two metals of equal mass with different heat capacities are subjected to the same amount of heat. Which undergoes the smaller change in temperature?
a) The metal with the higher heat capacity.
b) The metal with the lower heat capacity.
c) Both undergo the same temperature change.
d) You need to know the initial temperatures of the metals.
e) You need to know which metals you have.
47. The ΔH value for the reaction: 2Hg (l) + O_2 (g) \rightarrow 2HgO (s) is -181.6 kJ. How much heat is released when 32.5 g of Hg is reacted with oxygen?
a) 14.7 kJ
b) 29.5 kJ
c) 7.37 kJ
d) 5.59 kJ
48. A 40.2-g sample of a metal is heated to 99.3°C and then placed in a calorimeter containing 120.0 g of water (specific heat $\text{J/g}\cdot^\circ\text{C}$) at 21.8°C . The final temperature of the water is 24.5°C . Which metal was used?
a) Aluminum (specific heat $0.89 \text{ J/g}\cdot^\circ\text{C}$)

- b) Copper (specific heat $0.20 \text{ J/g}\cdot^\circ\text{C}$)
 c) Iron (specific heat $0.45 \text{ J/g}\cdot^\circ\text{C}$)
 d) Lead (specific heat $0.14 \text{ J/g}\cdot^\circ\text{C}$)
49. What is the maximum number of electrons in an atom that can have the quantum numbers:
 $n = 4, l = 2, m_s = +1/2$
- a) 2
 b) 3
 c) 5
 d) 7
 e) 10
50. How many unpaired electrons are found in the ground state phosphorous atom?
- a) 1
 b) 2
 c) 3
 d) 4
 e) 5
51. List the following elements in order of increasing first ionization energy: Li, Na, C, O, F .
- a) $\text{Li} < \text{Na} < \text{C} < \text{O} < \text{F}$
 b) $\text{Na} < \text{Li} < \text{C} < \text{O} < \text{F}$
 c) $\text{F} < \text{O} < \text{C} < \text{Li} < \text{Na}$
 d) $\text{Na} < \text{Li} < \text{F} < \text{O} < \text{C}$
 e) $\text{Na} < \text{Li} < \text{C} < \text{F} < \text{O}$
52. Rank the following in order of increasing size: $\text{Co}^{3+}, \text{Fe}^{2+}, \text{Fe}^{3+}, \text{Fe}$:
- a) $\text{Co}^{3+} < \text{Fe}^{2+} < \text{Fe}^{3+} < \text{Fe}$
 b) $\text{Co}^{3+} < \text{Fe}^{3+} < \text{Fe}^{2+} < \text{Fe}$
 c) $\text{Fe}^{3+} < \text{Fe}^{2+} < \text{Co}^{3+} < \text{Fe}$
 d) $\text{Fe} < \text{Co}^{3+} < \text{Fe}^{2+} < \text{Fe}^{3+}$
 e) $\text{Fe}^{2+} < \text{Fe}^{3+} < \text{Co}^{3+} < \text{Fe}$
53. Rank the following in order of increasing carbon-oxygen bond length:
 $\text{CO}_3^{2-}, \text{CO}, \text{CH}_3\text{OH}, \text{CO}_2$.
- a) $\text{CO}_3^{2-} < \text{CO} < \text{CH}_3\text{OH} < \text{CO}_2$
 b) $\text{CO} < \text{CO}_3^{2-} < \text{CO}_2 < \text{CH}_3\text{OH}$
 c) $\text{CH}_3\text{OH} < \text{CO}_3^{2-} < \text{CO}_2 < \text{CO}$
 d) $\text{CO} < \text{CO}_2 < \text{CO}_3^{2-} < \text{CH}_3\text{OH}$
54. Consider the following molecules:
- I. BF_3
 II. CHBr_3 (C is the central atom)
 III. Br_2
 IV. XeF_2
 V. CO
 VI. SF_4

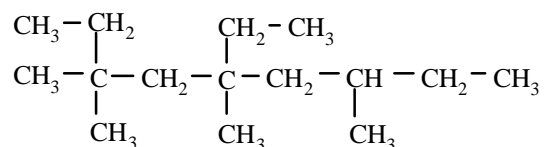
Which of the above molecules have a net dipole moment of zero?

- a) II, V
 b) I, III, IV

- c) III, IV, V
 d) I, III, IV, VI
 e) none of them
55. Which of the following has the highest vapor pressure?
- a) H₂O (s) at 0 °C
 b) H₂O (l) at 25 °C
 c) H₂O (l) at 50 °C
 d) H₂O (l) at 75 °C
56. Rank the following in order of increasing melting point: NaCl, MgO, glucose (C₆H₁₂O₆), Br₂.
- a) MgO < NaCl < glucose < Br₂
 b) Br₂ < NaCl < glucose < MgO
 c) Br₂ < glucose < MgO < NaCl
 d) Br₂ < glucose < NaCl < MgO
 e) glucose < Br₂ < NaCl < MgO
57. What is the hybridization of carbon (3) and approximate bond angle (a) in the structure shown below?



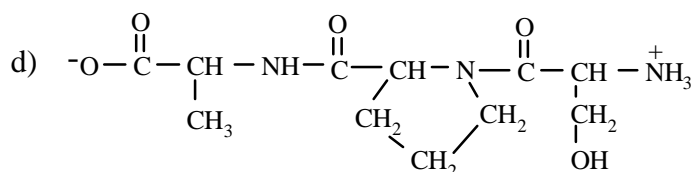
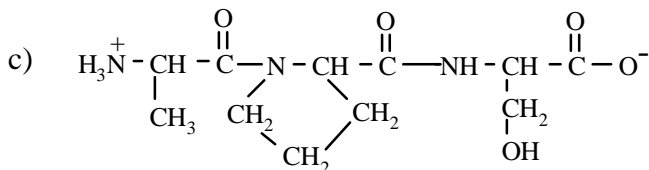
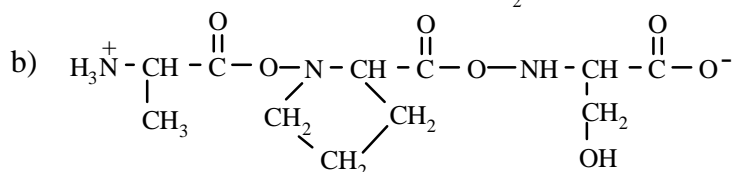
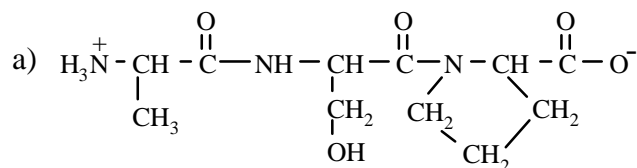
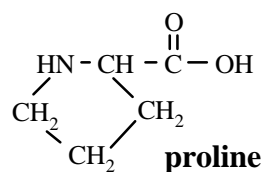
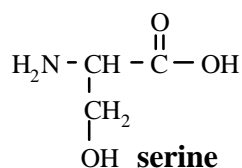
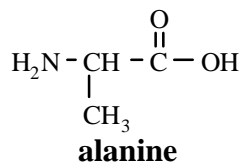
- a) sp², 120 °
 b) sp³, 120 °
 c) sp², 90 °
 d) sp³, 109 °
 e) sp³, 109 °
58. Select the correct IUPAC name for the following alkane:



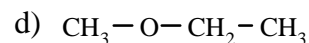
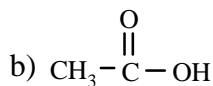
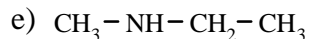
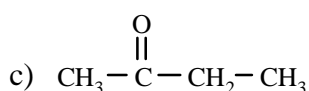
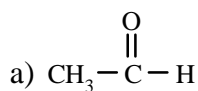
- a) 2,4-diethyl-2,4,6-trimethyloctane
 b) 5-ethyl-3,3,5,7-tetramethylnonane
 c) 2-ethyl-4-ethyl-2,4,6-trimethyloctane
 d) 5-ethyl-3,5,7,7-tetramethylnonane
 e) 1-isobutyl-3,5-dimethyl-5-ethylheptane
59. What is the oxidation number of chlorine in chloric acid (HClO₃)?
- a) -1
 b) 0

- c) +1
- d) +3
- e) +5

60. Which of the following best represents the correct structure of the tripeptide Ala-Pro-Ser?



61. Which of the following contains an aldehyde functional group?



62. What is the hybridization of the iodine and the approximate F-I-F bond angle in IF_3 ?

- a) $\text{sp}^2, 90^\circ$
- b) $\text{sp}^2, 120^\circ$
- c) $\text{sp}^3, 90^\circ$

- d) sp^3d , 90°
 e) sp^3d , 120°
63. Which of the following compounds contains a polar covalent bond?
- a) Cl_2
 b) HCl
 c) $NaCl$
 d) $MgCl_2$
64. When a water molecule forms a hydrogen bond with another water molecule, which atoms are involved in the interaction?
- a) A hydrogen from one molecule and an oxygen from the other molecule
 b) A hydrogen from one molecule and a hydrogen from the other molecule
 c) An oxygen from one molecule and an oxygen from the other molecule
 d) Two hydrogens from one molecule and an oxygen from the other molecule
 e) Two hydrogens from one molecule and a hydrogen from the other molecule
65. The two depictions of diazomethane shown below would be considered:
- $$CH_2=N^+=\ddot{N}^- \quad \text{and} \quad ^-\ddot{C}H_2-N^+\equiv N:$$
- a) equilibrium structures
 b) isomers
 c) resonance structures
 d) unrelated structures
66. Based on the phase diagram shown below, which of the following statements are correct?

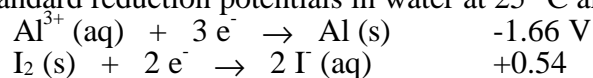
(see Zumdahl test bank, pg. 233)

- I. Sublimation occurs at a point in the transformation that occurs along a straight line from point A to point F.
 II. C and E represent points where the gas and liquid phases are in equilibrium.
 III. ΔH_{vap} can be measured at point B.
 IV. Molecules at point D have a greater average kinetic energy than those at point F.
 V. The temperature at point E is called the critical temperature of the compound.
- a) II, V
 b) I, III, IV
 c) I, II, III

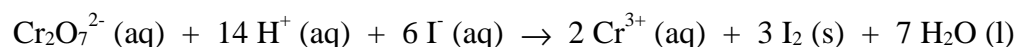
- d) II, IV, V
 e) I, II, IV
67. The unit cell in a certain lattice consists of a cube formed by an anion at each corner, an anion in the center, and a cation at the center of each face. The unit cell contains a net:
- a) 9 anions and 6 cations
 b) 5 anions and 3 cations
 c) 2 anions and 3 cations
 d) 3 anions and 4 cations
 e) 2 anions and 2 cations

68. Calculate the standard emf for a cell that employs the following overall cell reaction:
- $$2 \text{Al (s)} + 3 \text{I}_2 \text{(s)} \rightarrow 2 \text{Al}^{3+} \text{(aq)} + 6 \text{I}^- \text{(aq)}$$

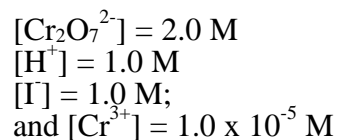
The standard reduction potentials in water at 25 °C are:



- a) + 4.94 V
 b) - 2.20 V
 c) + 2.20 V
 d) - 1.12 V
 e) - 1.70 V
69. Calculate the emf generated by a cell (at 25 °C) containing potassium dichromate and sulfuric acid:



when the concentrations are:



The standard emf for this reaction is $E^\circ = 0.79 \text{ V}$.

- a) 0.79 V
 b) 0.69 V
 c) 2.5 V
 d) 1.4 V
 e) 0.89 V
70. What is the product of β^- emission from iodine-131?
- a) Te-131
 b) Xe-131
 c) Sb-127

- d) I-132
e) Xe-54
71. Cobalt-60 has a half-life of 5.27 yr. The cobalt-60 in a radiotherapy unit must be replaced when its radioactivity falls to 75 % of the original sample. If the original sample was purchased in January of 2000, on what approximate date will it be necessary to replace the cobalt-60?
- a) March 2002
b) June 2000
c) January 2001
d) September 2003
e) May 2005
72. If the pH of orange juice is 3.70, what is the hydroxide ion concentration in orange juice?
- a) 2.0×10^{-4} M
b) 3.7×10^{-7} M
c) 5.0×10^{-11} M
d) 2.5×10^{-2} M
e) 3.7×10^{-10} M
73. A 1.5 mL sample of 1.0 M Na_3PO_4 (aq) is diluted to a total solution volume of 2.5 L. What is the sodium ion concentration in the resulting solution?
- a) 0.60 mM
b) 1.8 mM
c) 18 mM
d) 1.5 mM
e) 0.020 mM
74. Using the bond enthalpy values provided, estimate ΔH for the following reaction:



Average bond enthalpies (kJ/mol)

<u>Single bonds</u>		<u>multiple bonds</u>	
N-H	391	N=N	418
N-N	163	N≡N	941
H-H	436		

- a) - 868 kJ
b) + 437 kJ
c) + 86 kJ
d) - 86 kJ
e) + 350 kJ
75. In the laboratory, it is sometimes necessary to dilute concentrated solutions of strong acids. What procedure should you use?
- a) Always add the water to the acid slowly
b) Always add the water to the acid quickly

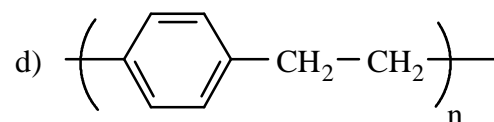
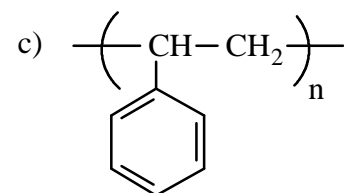
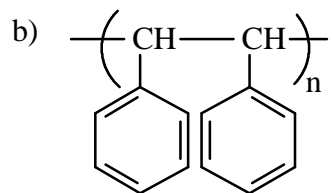
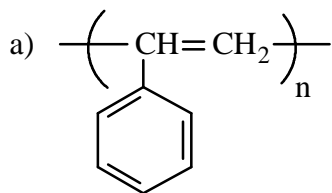
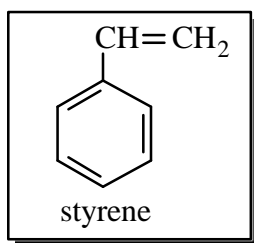
- c) Always add the acid to the water slowly
d) Always add the acid to the water quickly
76. A solution of hydrogen peroxide is 30.0 % H_2O_2 by mass and has a density of 1.11 g/cm^3 . The molarity of the solution is:
- a) 9.79 M
b) 3.00 M
c) 7.95 M
d) 0.979 M
e) 18.5 M
77. You plan to prepare 100.0 mL of 0.100 M $\text{Co}(\text{NO}_3)_2$ (aq). What glassware should you use to prepare this solution?
- a) graduated cylinder
b) volumetric flask
c) beaker
d) Erlenmeyer flask
78. How many electrons does the sulfide ion have in its 3p subshell?
- a) 2
b) 4
c) 6
d) 7
e) 8
79. Which element has its first, second, and third shells filled, with 4 electrons in its fourth shell?
- a) Zr
b) Ca
c) Ge
d) Ti
e) Cr
80. A certain sample of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) contains 3.25×10^{24} hydrogen atoms. What is the mass of this sample?
- a) 3.25 g
b) 81.0 g
c) 5.39 g
d) 971 g
81. If 0.500 L of a 0.600 M aqueous SnSO_4 solution is electrolyzed for a period of 30.00 minutes using a current of 4.60 A and inert electrodes, what is the final concentration of tin(II) ion remaining in the solution?
- a) 0.0429 M
b) 0.0858 M
c) 1.03 M
d) 0.514 M

e) 0.257 M

82. The *watt* is the SI unit of *power*, the measure of energy per unit time, i. e. $1 \text{ W} = 1 \text{ J/s}$. A typical laser used as a pointer in lecture presentations outputs red light of wavelength 6300 \AA , with a power of 5.0 mW . The laser is pointed at a surface for 2.0 minutes . How many photons of laser light will strike the surface during this time interval?

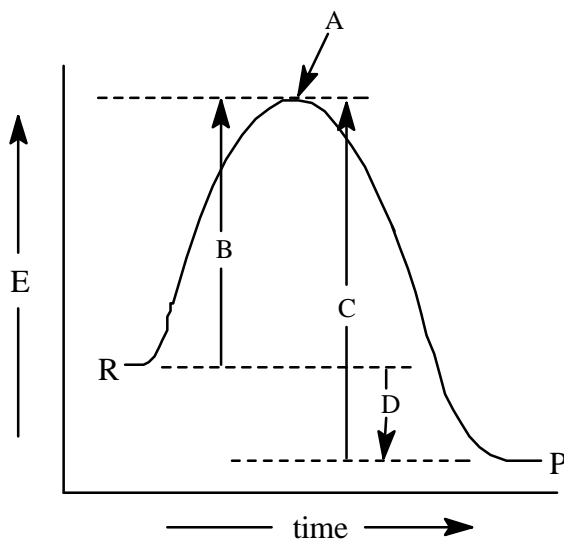
- a) 1.6×10^{16} photons
- b) 1.9×10^{18} photons
- c) 1.9×10^{20} photons
- d) 3.2×10^{18} photons
- e) 6.0×10^{23} photons

83. The monomer styrene (shown below) can be polymerized free radically to prepare polystyrene, a commercially important polymer used in a variety of applications. Which of the following choices best represents the structure of polystyrene?



84. An open beaker contains a salt solution. Assuming constant temperature and pressure, the vapor pressure of the solution:
- increases over time
 - decreases over time
 - stays the same over time
 - Need to know which salt is in the solution to answer this.
 - Need to know the temperature and pressure to answer this.
85. A 5.50-gram sample of a nonelectrolyte is dissolved in 250. grams of benzene. The freezing point of this solution is 1.02 °C below that of pure benzene. What is the molar mass of this compound? (Note: K_f for benzene is 5.12 °C/m .)
110. g/mol
 - 27.5 g/mol
 - 43.8 g/mol
 - 220 g/mol
86. Calculate the pH of a 0.100 M $\text{HC}_2\text{H}_3\text{O}_2$ (aq) at 25 °C. The K_a for $\text{HC}_2\text{H}_3\text{O}_2$ (acetic acid) is 1.8×10^{-5} .
- 1.00
 - 2.87
 - 0.0013
 - 2.37
87. Consider the titration of 25.0 mL of 0.100 M $\text{HC}_2\text{H}_3\text{O}_2$ (aq) with NaOH (aq) at 25 °C. At the equivalence point the pH is:
- 0
 - less than 7
 - 7
 - greater than 7
 - 14
88. Calculate the pH of a 0.10 M NaOCl (aq) solution at 25 °C. The K_a of HOCl is 3.5×10^{-8} .
- 3.77
 - 4.23
 - 9.77
 - 10.23
 - 13.00
89. Calculate the pH of a solution made by combining 10.0 mL of 0.100 M HCl (aq) and 10.0 mL of 0.200 M NaOH (aq) at 25 °C.
- 1.00
 - 1.30
 - 7.00

- d) 12.00
e) 12.70
90. Which of the following compounds would you dissolve in a solution of aqueous NH_3 to make a buffer?
- a) NaCl
b) NaOH
c) NH_4Cl
d) CH_3NH_2
91. Which of the following ions would be the weakest Bronsted-Lowry base?
- a) Cl^-
b) F^-
c) OH^-
d) SO_4^{2-}
92. Which of the following best defines a **neutral** aqueous solution?
- a) no ions are present
b) $[\text{H}^+] = [\text{OH}^-]$
c) $\text{pH} = 7.0$
d) $K_w = 1 \times 10^{-14}$
93. Consider the following qualitative reaction energy diagram for the hypothetical reaction $\text{R} \rightarrow \text{P}$. Which **best** describes the activation energy for this reaction?



- a) A
b) B
c) C
d) D
94. Which of the following phase transitions is the most exothermic?
- a) crystallization
b) melting

- c) vaporization
d) sublimation
95. For the phase transition $\text{CCl}_4(\text{l}) \rightarrow \text{CCl}_4(\text{g})$, $\Delta H_{\text{vap}} = 32.6 \text{ kJ/mol}$ and $\Delta S_{\text{vap}} = 93.2 \text{ J/mol}\cdot\text{K}$. What is the boiling point of carbon tetrachloride (CCl_4)?
- a) $76.6 \text{ }^\circ\text{C}$
b) $0.350 \text{ }^\circ\text{C}$
c) $350. \text{ }^\circ\text{C}$
d) $81.5 \text{ }^\circ\text{C}$
e) $100. \text{ }^\circ\text{C}$
96. Calculate the molar solubility of CeF_3 in water at 25°C . $K_{\text{sp}} = 8.0 \times 10^{-16}$ for CeF_3 .
- a) $1.3 \times 10^{-4} \text{ M}$
b) $3.1 \times 10^{-6} \text{ M}$
c) $9.7 \times 10^{-5} \text{ M}$
d) $7.4 \times 10^{-5} \text{ M}$
97. Consider the following reaction at equilibrium at 298 K : $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2 \text{NO}_2(\text{g})$. The equilibrium mixture contains 0.136 atm of NO_2 and 0.208 atm N_2O_4 . Calculate ΔG° for this reaction.
- a) $-6.00 \times 10^3 \text{ J/mole}$
b) $6.00 \times 10^3 \text{ J/mole}$
c) 59.2 J/mole
d) 1050 J/mole
98. Which of the following transformations would have the greatest entropy increase?
- a) the melting of ice
b) the condensation of steam
c) the vaporization of water
d) the freezing of water
99. Dinitrogen pentoxide decomposes according to the following reaction:
- $$2 \text{N}_2\text{O}_5(\text{g}) \rightarrow 4 \text{NO}_2(\text{g}) + \text{O}_2(\text{g})$$
- In an experiment, the concentration of N_2O_5 is monitored as the reaction takes place. A plot of $\ln[\text{N}_2\text{O}_5]$ vs time results in a linear relationship given by:
- $$\ln[\text{N}_2\text{O}_5] = -0.00050 \text{ s}^{-1} \cdot (\text{time}) - 2.00.$$
- The half life for this reaction is:
- a) 0.00050 s
b) 4.0 s
c) 1400 s
d) 55 s
100. What are the appropriate units for the rate constant in the following rate law:
- $$\text{Rate} = k [\text{ClO}_2]^2 [\text{OH}^-]$$
- a) s^{-1}
b) Ms^{-1}
c) $\text{M}^{-1}\text{s}^{-1}$

d) M^2s^{-1}

INDIANA SECTION of the AMERICAN CHEMICAL SOCIETY

High School Scholarship Exam Answer Key

April 21, 2001



1. b	21. a	41. d	61. a	81. d
2. e	22. e	42. d	62. d	82. b
3. a	23. a	43. a	63. b	83. c
4. c	24. c	44. b	64. a	84. b
5. d	25. d	45. d	65. c	85. a
6. c	26. d	46. a	66. e	86. b
7. a	27. b	47. a	67. c	87. d
8. d	28. d	48. c	68. c	88. d
9. c	29. b	49. c	69. e	89. e
10. e	30. b	50. c	70. b	90. c
11. a	31. a	51. b	71. a	91. a
12. d	32. d	52. b	72. c	92. b
13. d	33. a	53. d	73. b	93. b
14. e	34. c	54. b	74. d	94. a
15. b	35. c	55. d	75. c	95. a
16. d	36. d	56. d	76. a	96. d
17. a	37. e	57. e	77. b	97. b
18. d	38. c	58. b	78. c	98. c
19. c	39. b	59. e	79. c	99. c
20. e	40. c	60. c	80. b	100. d