DIRECTIONS

- Put your name, school, and test number on the bubble sheet, as follows;

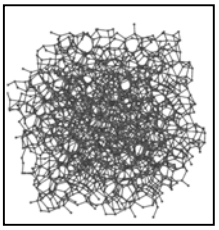
  NAME__Your_Name_____

  SUBJECT__School_____

  PERIOD_____DATE_____Test Number____

- If you are using a graphing calculator, clear its memory **now**.
- There are 85 questions, and the exam will last 100 minutes.
- When you have selected your answer to each question, blacken the corresponding space on the answer sheet using a soft, #2 pencil. Make a heavy, full mark, but no stray marks. If you decide to change an answer, erase the unwanted mark very carefully.
- There is only one correct answer to each question. Any questions for which more than one response has been blackened **will not be counted**.
- Your score is based solely on the number of questions you answer correctly. **It is to your advantage to answer every question.**
- When you are told to start the exam, you may tear off this sheet and the periodic table sheet below this one.
- After the test is over and the proctors have collected the bubble sheets, you may take this exam home with you.
- Answers will be posted in the registration area after the examination and on-line at NESACS.com.
- Prize winners and qualifiers will be notified within 3 days or sooner.
- Good luck!

1. The name of the carbon allotrope shown to the right is:

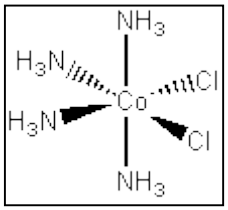


A. charcoal B. diamond C. bucky ball D. nanotube

2. The two types of pure substances are:

A. elements and subatomic particles
B. protons and electrons
C. atoms and compounds
D. homogenous and heterogeneous

3. The name of the compound whose overall formula is $Co(NH_3)_6Cl_3$ and has a piece of its structure shown to the right is:



A. *cis*-tetraamminedichlorocobalt(III) chloride
B. *trans*-tetraamminedichlorocobalt(III) chloride
C. hexaamminecobalt(III) chloride
D. pentaamminechlorocobalt(III) chloride

4. The element whose name comes from the Greek for "*color*" because of its many colored compounds is:

A. copper B. nickel C. chromium D. cobalt

5. A chemistry lab takes advantage of the reactivity of aluminum metal to make alum, $KAl(SO_4)_2 \cdot 12H_2O$ according to the equation below. Balance the equation with the smallest whole number coefficients and select the answer that has the **sum** of coefficients:

_____ Al + _____ KOH + _____ H_2SO_4 + _____ H_2O → _____ $KAl(SO_4)_2 \cdot 12H_2O$ + _____ H_2

A. 15 B. 17 C. 34 D. 35

6. Which of the following will be found on a Material Safety Data Sheet (MSDS)?

A. Health hazards
B. Precautions for Safe Handling and Use
C. Fire and Explosion Hazard Data
D. All of the above

7. Teachers just love it when students request the proper equipment when doing a laboratory. To impress your teacher, you ask for the item to the right as a:

A. wash bottle
B. dropper bottle
C. squeeze bottle
D. whatchamacallit bottle

8. Balance drift is a common problem when you are trying to weigh a sample accurately. Which of the following would contribute to balance drift?

A. The temperatures of the balance and material to be weighed are different.
B. Air currents are present in the lab.
C. The sample is gaining or losing mass.
D. All of the above could cause drift.

9. Which of the following statements about electrons is false?

A. Electrons repel each other.
B. Electrons attract protons.
C. Electrons have a charge of 1+.
D. Electrons are much lighter than neutrons.

10. Which of the following ions will produce a brilliant and intense red color in a flame test?

A. K^+ B. Cu^{2+} C. Li^+ D. Ba^{2+}

11. The formula of the hydrate, $CaSO_4 \bullet xH_2O$, from the data to the right is: ($CaSO_4$ = 136.14 g/mole, O = 16.00 g/mole, H = 1.01 g/mole)

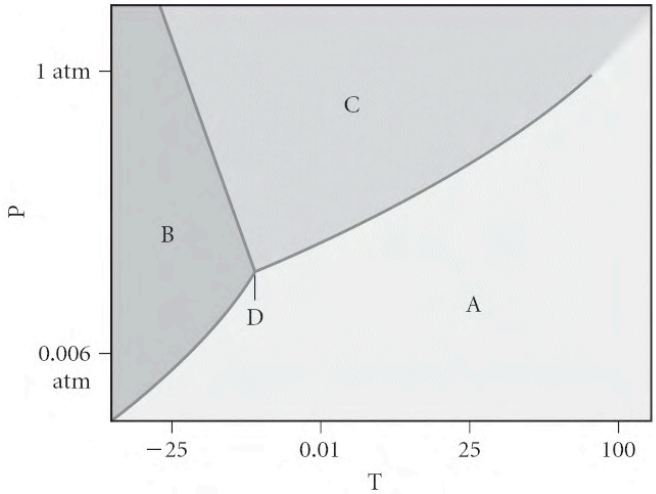
Mass of hydrate	2.903 grams
Mass of anhydride	2.723 grams

A. $CaSO_4 \bullet ½ H_2O$ B. $CaSO_4 \bullet H_2O$ C. $CaSO_4 \bullet 2H_2O$ D. $CaSO_4 \bullet 6H_2O$

12. Nanotechnology is the process of manipulating one atom or molecule at a time. The words "Nano USA" (right) were written with a scanning tunneling microscope with 112 carbon monoxide (CO) molecules on a copper surface as the 'canvas'. Each CO molecule is 3.0 nm wide. The number of CO molecules that could be written side-by-side across a human hair 5.0 x 10^{-3} inches in diameter is (1 nm = 10^{-9} m, 1 inch = 2.54 cm):

A. 42 thousand B. 4.2 million C. 65 million D. 420 million

13. The appropriate labels to the phase diagram shown below are:



A. A = liquid, B = solid, C = gas, D = critical point
B. A = gas, B = solid, C = liquid, D = triple point
C. A = gas, B = liquid, C = solid, D = critical point
D. A = solid, B = gas, C = liquid, D = triple point

14. Balance the equation below and find the limiting reactant (LR) and the grams of nitrogen that can be formed from 50.0 g N_2O_4 and 45.0 g N_2H_4. Molar masses are: N_2O_4 = 92.02 g/mol, N_2H_4 = 32.05 g/mol, N_2 = 28.02 g/mole

$$\_\_\_\_\_N_2O_4(l) + \_\_\_\_\_N_2H_4(l) \rightarrow \_\_\_\_\_N_2(g) + \_\_\_\_\_H_2O(g)$$

A. LR = N_2H_4, 59.0 g N_2 formed
B. LR = N_2O_4, 105 g N_2 formed
C. LR = N_2O_4, 45.7 g N_2 formed
D. LR = N_2H_4, 13.3 g N_2 formed

15. Above what atomic number are there no stable isotopes of any element?

A. 82 B. 83 C. 89 D. 92

16. Two solutions, initially at 24.69 °C, are mixed in a coffee cup calorimeter (C_{cal} = 105.5 J/°C). When 200.0 mL of 0.100 M $AgNO_3$ is mixed with a 100.0 mL of 0.100 M NaCl, the temperature in the calorimeter rises to 25.16 °C. The density of the mixture is 1.00 g/mL and its heat capacity is 4.184 J/g ·°C. The $\Delta H°_{rxn}$ for the reaction per mole of AgCl is:

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

A. -640 J/mol B. -32 kJ/mol C. -59 kJ/mol D. -64 kJ/mol

For Questions 17 -19 use the following information:

Blood is buffered by carbonic acid-bicarbonate ion system. Normal blood plasma is 0.024 M in HCO_3^- and 0.0012 M in H_2CO_3. The pK_a for H_2CO_3 at body temperature is 6.10. The volume of blood in a normal teenager is 5.0 L.

17. What is the pH of blood plasma?

A. 7.20 B. 7.40 C. 7.60 D. 8.00

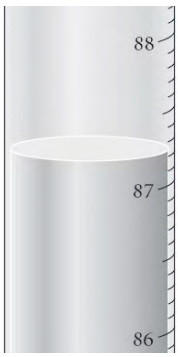
18. What mass of HCl could be neutralized by the blood's buffering system before the pH falls below 7.00 which would result in death? Molar mass of HCl = 36.45 g

A. 0.32 g B. 1.2 g C. 3.4 g D. 4.2 g

19. What mass of NaOH could be neutralized by the buffering system in blood before the pH goes above 7.80 which would result in death? Molar mass of NaOH = 40.00 g

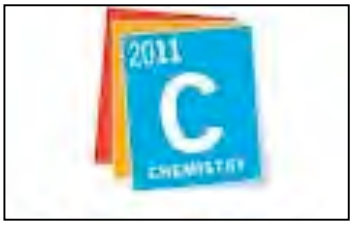
A. 0.14 g B. 0.33 g C 1.2 g D. 4.7 g

20. The temperature to the right with the correct number of significant figures is:



A. 87°C B. 87.2°C C. 87.20°C D. 87.200°C

21. The pin to the right represents:



A. International Year of Chemistry-2011
B. International Year of Carbon-2011
C. International Year of Vitamin C-2011
D. International Year of the C Average Chemistry Student-2011

22. Which of the following signs should be prominently displayed in a chemistry laboratory?

I.

II.

III.

IV.

A. I only B. II only C. I and II only D. All should be prominently displayed

23. A freshly prepared sample of curium-243 undergoes 3312 disintegrations per second. After 6.00 years the activity of the sample declines to 2755 disintegrations per second. The half-life of curium-243 is:

A. 4.99 yr B. 22.6 yr C. 52.1 yr D. 147 yr

24. The following equilibrium reaction has $K_c = 0.516$.

$FeO(s) + CO(g) \leftrightarrows Fe(s) + CO_2(g)$

In a two-liter container, 0.130 moles of $CO(g)$ with excess $FeO(s)$ are allowed to react and reach equilibrium at 1000 °C. The moles of CO, Fe, and CO_2 at equilibrium are:

	moles CO	moles CO_2	moles Fe
A.	0.108	0.022	0.022
B.	0.044	0.086	0.044
C.	0.086	0.044	0.044
D.	0.067	0.062	0.062

25. The pH of a 0.127 M solution of Na_2S is: $K_{a1}(H_2S) = 1.05 \times 10^{-8}$, $K_{a2}(H_2S) = 1.0 \times 10^{-19}$, $K_w = 1.0 \times 10^{-14}$

A. 10.54 B. 11.95 C. 13.10 D. 16.05

26. Dimethylglyoxime (DMG), used to quantitatively precipitate nickel, contains only C, H, N, and O and has a molecular mass of 115 ± 5 grams. In a combustion analysis, a 2.500 g sample of DMG yields 3.807 g CO_2 and 1.552 g H_2O. In a separate experiment, the nitrogen in a 2.500 g sample of DMG is converted to NH_3, which is then neutralized by bubbling it into 50.0 mL of 0.500 M H_2SO_4. After bubbling in the NH_3, the excess H_2SO_4 was neutralized with 27.50 mL of 0.250 M NaOH. The molecular formula of DMG is:

	Molar Mass
CO_2	44.0
H_2O	18.0
NH_3	17.0
C	12.0
H	1.01
N	14.0
O	16.0

A. $C_4H_8N_2O_2$ B. $C_4H_{12}N_2O_2$ C. $C_3H_9N_3O_2$ D. $C_3H_9NO_3$

27. The following elements are in the fourth period of the periodic table: Ca, Mn, Co, Zn, Se. Of those listed, the ones that have unpaired electrons in the ground state electron configuration are:

A. Ca, Mn, Co, Zn B. Mn, Co, Zn C. Ca, Zn, Se D. Mn, Co, Se

28. If a liter of CO_2 is compared to a liter of H_2, both at 25 $^{\circ}$C and one atmosphere pressure, then:

A. The mass of one liter of CO_2 equals the mass of one liter of H_2.
B. There are more H_2 molecules than CO_2 molecules.
C. The average kinetic energy of the CO_2 molecules is greater than that of the H_2 molecules.
D. The CO_2 molecules are on the average moving more slowly than the H_2 molecules.

29. From a supermarket a 12 pack of cans of Coca-Cola (12 oz per can) costs $3.99, but a 2-L bottle costs only $1.29. The savings per liter of the bottle over the 12 pack is: (1 liter = 1.0567 quarts, 32 ounces = 1 quart)

A. 19 ¢ B. 24¢ C. 29¢ D. There is no savings.

30. The rate law for the reaction below is rate = $k[NO]^2[O_2]$. Which of the following proposed mechanisms is **most** likely?

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

A.	$2NO + O_2 \rightarrow 2\ NO_2$	
B.	$2\ NO \leftrightarrows N_2O_2$ $N_2O_2 + O_2 \rightarrow 2\ NO_2$	fast slow
C.	$NO + O_2 \rightarrow NO_2 + O$ $NO + O \rightarrow NO_2$	slow fast
D.	$NO + O_2 \leftrightarrows NO_3$ $NO_2 + NO_3 \rightarrow N_2O_5$	fast slow

31. If you catch on fire, you should:

A. Panic! Yell ***FIRE*** at the top of your lungs to let others know about it. Be sure to run as quickly as possible to blow out the flame.
B. Head for the fire extinguisher and ask someone to turn it on you. If you can't get someone to help, ask your instructor.
C. Pull the fire alarm and look for help. Hope the fire doesn't burn you too badly before you can take some form of action.
D. Smother the flame. Those blankets in the lab are there for a reason. Some fire doesn't really care about water, but all flames need oxygen. Get help, too. You weren't working alone in the lab though, right?

32. The element with the lowest first ionization energy is:

A. H B. O C. F D. Xe

33. A thin layer of gold is plated on a metal surface. The metal surface is 7.75 in^2. A current of 3.25 A is applied to a solution of Au^{3+}. The time to deposit 1.00 x 10^{-3} cm thick of gold on the one side of the metal plate is: (2.54 cm = 1 inch (exact), density (gold) = 19.3 g/cm^3, 1 Faraday = 96,500 coulombs/mole, Au = 197.0 g/mole)

A. 69 seconds B. 171 seconds C. 436 seconds D. 1309 seconds

34. The ΔH for the reaction below, given the following reactions and their ΔH values, is:

$HCl(g) + NaNO_2(s) \rightarrow HNO_2(l) + NaCl(s)$

A. -79 kJ
B. -45 kJ
C. -36 kJ
D. +45 kJ

$2NaCl(s) + H_2O(l) \rightarrow 2HCl(g) + Na_2O(s)$	ΔH = 508 kJ
$NO(g) + NO_2(g) + Na_2O(s) \rightarrow 2NaNO_2(s)$	ΔH = -427 kJ
$NO(g) + NO_2(g) \rightarrow N_2O(g) + O_2(g)$	ΔH = -43 kJ
$2HNO_2(l) \rightarrow N_2O(g) + O_2(g) + H_2O(l)$	ΔH = 34 kJ

For questions 35 and 36, use the following information:

A 5.00 gram sample of a dry mixture of potassium hydroxide (56.11 g/mole), potassium carbonate (138.21 g/mole), and potassium chloride (74.55 g/mole) is reacted with 0.100 liter of 2.0 molar HCl solution.

35. A 249 milliliter sample of dry CO_2 gas, measured at 22 °C and 740 torr, is obtained from the reaction. What is the percentage of potassium carbonate in the mixture? (R = 0.08206 L·atm / mole· K)

A. 18.6 % B. 27.7 % C. 29.2 % D. 55.5 %

36. The excess HCl was titrated to the equivalence point with 86.6 milliliters of 1.50 molar NaOH. Calculate the percentage of potassium hydroxide in the original mixture.

A. 31.2 % B. 57.2% C. 69.6 % D. 79.5 %

For questions 37 and 38, use the following information:

Tungsten is obtained commercially by the reduction of WO_3 with carbon in an electric furnace according to the equation below.

	$WO_3(s)$	$CO_2(g)$
$\Delta H_f°$ (kJ/mole)	-840.	-395
$\Delta G_f°$ (kJ/mole)	-764.	-394

$$2\ WO_3(s) + 3\ C(s) \leftrightarrows 2\ W(s) + 3\ CO_2(g)$$

37. The value of the equilibrium constant at 298 K represented above is: (R = 8.314 J/mole· K)

A. 2.3×10^{-61} B. 0.33 C.0.33 D. 2.0×10^{60}

38. At what temperature in K will it become spontaneous, assuming ΔH and ΔS don't change much?

A. It will never be spontaneous B. 495 C. 990 D. 1682

39. An electrochemical cell to measure $[Cl^-]$ was made by placing a AgCl(s)-coated Ag wire in a 1.00 M KCl solution in one compartment of the cell. The unknown Cl^- solution is placed in the other compartment along with another AgCl(s)-coated Ag wire. The potential difference between the Ag wires was then measured with a voltmeter. The potential of the Ag wire in the compartment containing the unknown Cl^- was found to be +0.1445 Volts vs. the other Ag wire. The $[Cl^-]$ of the unknown solution is:
The Nernst Equation is: $E = E° - 0.0592/n \log Q$

A. 0.060 M B. 3.6×10^{-3} M C. 0.017 M D. 0.39 M

40. The energy required to heat a 100. g sample of benzene (78.11 g/mole) from 209 K to 329 K using the table below is:

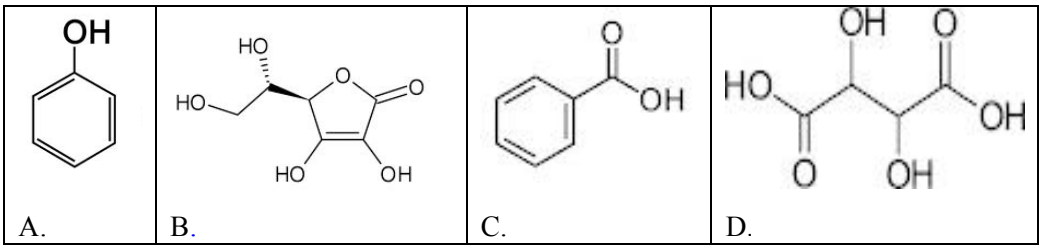
ΔH_{vap} = 33.9 kJ/mole	ΔH_{fus} = 9.8 kJ/mole	C_{gas} = 1.06 J/g°C	C_{liq} = 1.73 J/g°C
C_{solid} = 1.51 J/g°C	Melting point = 279 K	Boiling point = 353 K	

A. 18.7 kJ B. 28.4 kJ C. 31.8 kJ D. 62.1 kJ

41. From the Lewis structure for the molecule methyl acetylene, C_3H_4, the number of sigma (σ) and pi (π) bonds is:

A. 7 sigma, 3 pi B. 8 sigma, 1 pi C. 6 sigma, 2 pi D. 8 sigma, 2 pi

42. Phenol, also known as carbolic acid and phenic acid and whose major uses are its conversion to plastics is:



A. B. C. D.

43. The electron geometry, molecular geometry, and hybridization for CH_3^- is:

	Electron Geometry	Molecular Geometry	Hybridization
A.	tetrahedral	trigonal pyramidal	sp^3
B.	tetrahedral	tetrahedral	sp^3
C	trigonal pyramidal	trigonal pyramidal	sp^3
D	trigonal planar	trigonal planar	sp^2

44. The unit cell in a diamond crystal has a volume of 0.0454 nm^3 and the density of a diamond is 3.52 g/cm^3. The number of carbon atoms per unit cell is: 1 nm = 1 x 10^{-9} m, 1 gram = 6.022 x 10^{23} amu, C = 12.01

A. 2 B. 4 C. 6 D. 8

45. Gold metal dissolves in BrF_3 and KF to produce Br_2 and $KAuF_4$, according to the following **unbalanced** equation;

_____Au + _____BrF_3 + _____KF → _____$KAuF_4$ + _____Br_2

A 300. gram mixture containing equal masses of all three reactants is mixed. The amount of the gold salt, $KAuF_4$, formed is: (Au = 197.0 g/mole, BrF_3 = 136.9 g/mole, KF = 58.1 g mole, $KAuF_4$ = 312.1 g/mole)

A. 79.6 g B. 158 g C. 194 g D. 229 g

46. Place the following molecules in the table to the right in order of **increasing** X-Se-X bond angle, where X represents the outer atoms in each molecule.

SeO_2	$SeCl_6$	SeF_2

	Smallest X-Se-X	Middle X-Se-X	Largest X-Se-X
A.	$SeCl_6$	SeF_2	SeO_2
B.	SeF_2	SeO_2	$SeCl_6$
C.	SeF_2	$SeCl_6$	SeO_2
D.	$SeCl_6$	SeO_2	SeF_2

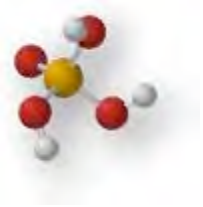
47. All of the common nitrogen oxides have positive values of $\Delta G_f°$ at 298 K, but only one of the nitrogen oxides listed below has a positive $\Delta S_f°$. The nitrogen oxide with a positive $\Delta S_f°$ is:

    A. N_2O B. NO C. NO_2 D. N_2O_5

48. The photon that has the highest speed is:

    A. radio waves B. blue light C. X-rays D. All travel at the same speed.

Use the following information for questions 49-52:



Concentrated phosphoric acid, H_3PO_4, is 85.0% H_3PO_4 by mass and has a density of 1.70 g/mL. Molar mass of H_3PO_4 is 98.00 g/mole.

49. The molarity of the concentrated H_3PO_4 is:

    A. 5.10 M B. 8.67 M C. 10.2 M D. 14.7 M

50. The molality of the concentrated H_3PO_4 is:

    A. 5.10 m B. 14.7 m C. 25.0 m D. 57.8 m

51. The milliliters of concentrated phosphoric acid are needed to prepare 500. mL of a 1.00 M H_3PO_4 solution are:

    A. 25.5 mL B. 33.9 mL C. 98.0 mL D. 339 mL

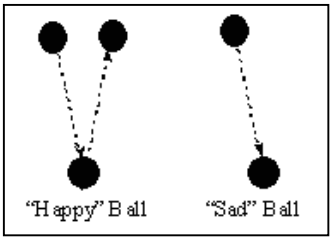
52. Phosphoric acid is deliberately added Coca-Cola to give it its sharp taste. But Coca-Cola has many other uses. See on-line: "51 Uses for Coca-Cola – the Ultimate List" http://www.wisebread.com/51-uses-for-coca-cola-the-ultimate-list

    Some uses given are:

    1. Remove grease or blood stains from clothing and fabrics.
    2. Remove rust; loosen a rusty bolt or clean car battery terminals.
    4. Kill slugs and snails; a small bowl of Coke will attract them, the acid will kill them.
    5. Help a lawn become lush and green.
    6. Clean burnt pans or de-scale a kettle.

    Coke has a pH of 2.525. The pH of a carbonated soda at typical carbonated pressures is 3.750. For phosphoric acid: $H_3PO_4(aq) \leftrightarrows H^+(aq) + H_2PO_4^-(aq)$, $K_{a1} = 7.5 \times 10^{-3}$ The molarity of phosphoric acid in coke is:

    A. 0.0018 M B. 0.0028 M C. 0.0039 M D. 0.0042 M



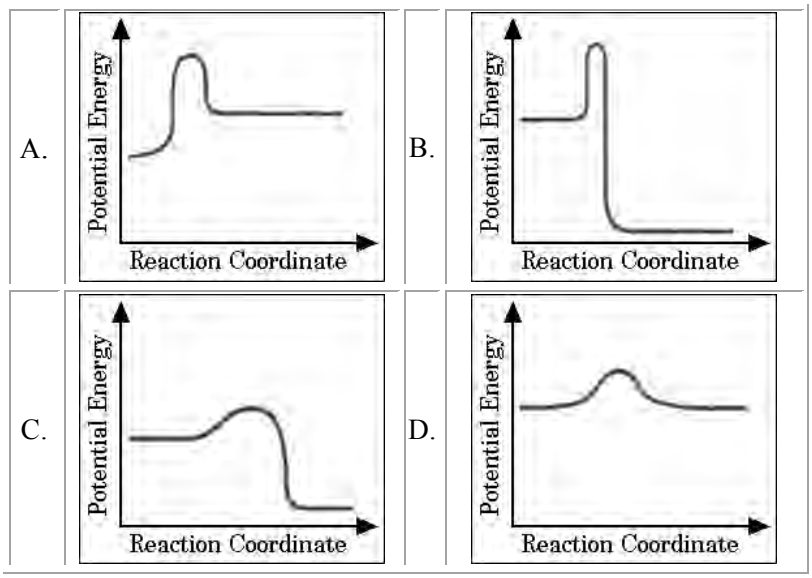
53. Two apparently identical black balls, made of the same polymer, were dropped onto a table. One bounced, the other didn't. You can conclude about the non-bouncing "sad" ball relative to the bouncing "happy" ball that:

    A. The form of the polymer used in the "sad" ball is likely to be highly cross-linked but the form of the polymer used in the "happy" ball contains fewer cross-links.
    B. The form of the polymer used in the "sad" ball is likely to be completely linear but the form of the polymer used in the "happy" ball is branched.
    C. The form of the polymer used in the "sad" ball is likely to have a lower average molecular mass than the form of the polymer used in the "happy" ball.
    D. The form of the polymer used in the "sad" ball is likely to have been formed with the use of plasticizers, but the form of the polymer used in the "happy" ball does not contain any plasticizers.

54. The estimated costs for remodeling the interior of an apartment are: three 1-gallon cans of paint at $13.22 each, two paint brushes at $9.53 each, and $135 for a helper. The total estimated cost with the appropriate significant figures is:

A. $\$1.9 \times 10^2$ B. \$194 C. \$193.7 D. \$193.72

55. The graph that describes the pathway of reaction that is exothermic and has low activation energy?



56. Chemists often erroneously assume that when they mix solvents, the volumes are additive. A solution was prepared by mixing 635 mL of methanol (molar mass = 32.04 g/mole) with 500. mL of water. The resulting solution molarity was 14.30 M. The density of methanol is 0.792 g/mL. The difference between volume of the solution and the total volume of the water and methanol that were mixed is:

A. 37 mL B. 98 mL C. 135 mL D. 224 mL

57. The number of the compounds below that are more soluble in acidic solution than in pure water is:

$AgCl$	$Al(OH)_3$	PbI_2	$ZnCO_3$	$BaSO_4$	$Ca_3(PO_4)_2$	MnS

A. 3 B. 4 C. 5 D. 6

58. Structural isomers differ from stereoisomers because:

A. Structural isomers have different formulas; stereoisomers have the same formula.
B. Stereoisomers have different chemical and physical properties; structural isomers have the same chemical and physical properties.
C. Structural isomers' atoms are bonded in the same order; stereoisomers' atoms are bonded in different orders.
D. Structural isomers' atoms are bonded in different orders; stereoisomers' atoms are bonded in the same order.

59. The number of the following names that are correct for the given formula are:

A. 1 B. 2 C. 3 D. 4

K_2O	dipotassium monoxide
$HNO_3(aq)$	hydrogen nitrate
$CuCO_3$	copper carbonate
$NaOCl$	sodium hypochlorite

60. Which of the following nuclides are most likely to decay by means of beta (β) decay?

A. I-126 B. Al-24 C. Ag-105 D. Cs-137

61. Consider a reaction: A + B + C→ Products. Several initial rates for this reaction were investigated and the following data were obtained: The rate law for the reaction is:

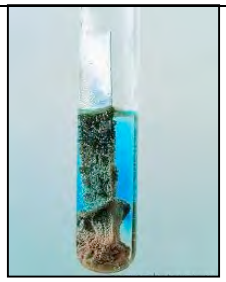
A. Rate = $k[A][B]^2[C]^2$
B. Rate = $k[A][B]^2[C]$
C. Rate = $k[A][B]^2[C]^3$
D. Rate = $k[A][B][C]^3$

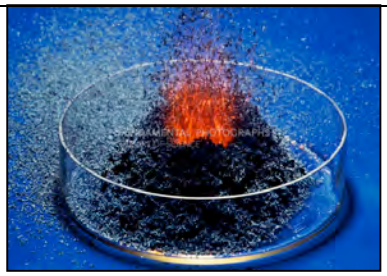
Run #	$[A]_0$	$[B]_0$	$[C]_0$	Rate
1	0.151 M	0.213 M	0.398 M	0.480 M/s
2	0.251 M	0.105 M	0.325 M	0.214 M/s
3	0.151 M	0.213 M	0.525 M	1.102 M/s
4	0.151 M	0.250 M	0.480 M	0.988 M/s

Use the following figures to answer questions 62-65:

Teachers just love to give demos that excite students and chemistry students have many memorable experiences of reactions in the laboratory. Identify the following four reactions from the images below.


A.


B.


C.


D.

62. copper(II) sulfate and zinc metal →

63. ammonium dichromate →

64. potassium iodide and lead(II) nitrate →

65. iron(III) oxide and aluminum metal →

66. Consider the following reaction: $4\ PCl_3(g) \leftrightarrows P_4(g) + 6\ Cl_2(g)$

If the initial concentration of $PCl_3(g)$ is 1.0 M, and "x" is the equilibrium concentration of $P_4(g)$, the correct equilibrium relation is:

A. $K_c = 6x^7$ B. $K_c = 6x^7/(1.0 - x)^4$ C. $K_c = (x)(6x)^6/(1.0 - 4x)^4$ D. $K_c = 6x^7/(1.0 - 4x)^4$

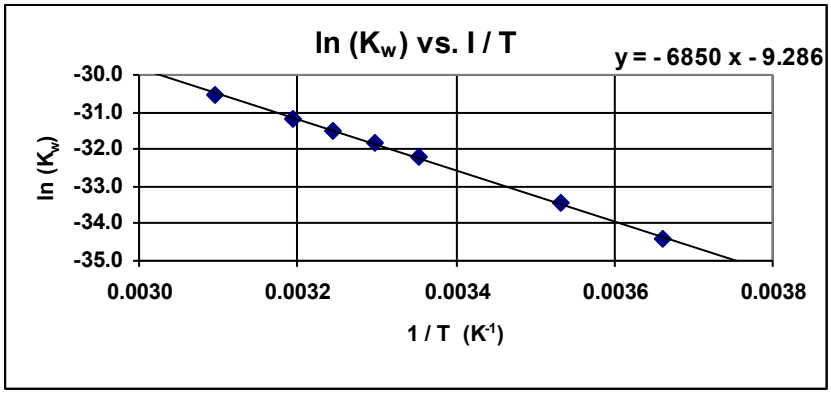
67. Small bubbles that form on the bottom of a beaker of water being heated before boiling are due to air coming out of solution. Find the total volume of nitrogen and oxygen gas that should bubble out of 1.5 L of tap water warming from 20 °C to 70°C. Assume that the water is saturated with nitrogen and oxygen at 20 °C, that all the gas bubbles come out at 70°C, and the total pressure is 1.0 atm. Use the Henry's law constants below.

Gas	k_H(M/atm) at 20 °C	k_H(M/atm) at 70 °C	Partial Pressure
O_2	1.3×10^{-3}	6.1×10^{-4}	0.21 atm
N_2	6.1×10^{-4}	3.0×10^{-4}	0.78 atm

A. 0.70 mL B. 13 mL C. 20. mL D. 45 mL

Use the following information for problems 68 and 69:

K_w	T (°C)
1.140×10^{-15}	0
2.930×10^{-15}	10
1.008×10^{-14}	25
1.471×10^{-14}	30
2.090×10^{-14}	35
2.916×10^{-14}	40



The values for the ion product of water, K_w, at various temperatures are given in the table above left. A student used these values to graph the natural log of K_w versus 1/T (in K) and obtained the graph to the above right. The student then found the linear trendline shown at the top of the graph: y = -6850 x - 9.286. (R = 8.314 J/mol·K)

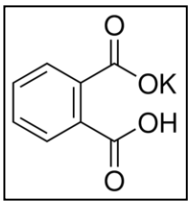
68. The ΔH° for the ion product of water is:

A. -57.0 kJ B. 6.85 kJ C. 57.0 kJ D. 77.2 kJ

69. The ΔS° for the ion product of water is:

A. -9.26 J/K B. -77.2 J/K C. 57.0 J/K D. 112 J/K

Use the following information for problems 70 and 71:



A student dissolved 32.676 grams of potassium hydrogen phthalate, KHP, a monoprotic acid, shown to the right, to a volume of 500.0 mL with distilled water. The molar mass of KHP is 204.22 g/mole and its K_a is 3.1×10^{-6} ($pK_a = 5.51$).

70. If 50.00 milliliters of the above solution is titrated to the equivalent point with an equal volume of NaOH, the pH of the solution at the equivalence point would be:

A. 7.00 B. 7.70 C. 9.36 D. 9.51

71. The student wants to make a buffer of pH = 7.00, how many grams of NaOH must be added to the 250. mL of the original solution that was prepared? Assume no change in volume. (NaOH = 40.00 g/mole)

A. 0.100 grams B. 0.200 grams C. 3.10 grams D. 6.20 grams

Use the following information for questions 72 and 73:

Nitrous acid, when dissolved in water, dissociates according to the following equation:

$$HNO_2(aq) \leftrightarrows H^+(aq) + NO_2^-(aq)$$

A solution is prepared by dissolving 7.050 g of HNO_2 (Molar mass = 47.01 g/mole) in 1.000 kg of water. Its freezing point was found to be -0.2929 °C. K_f (H_2O) = 1.86 °C/m

72. The percent fraction of the acid that dissociated is:

A. 0.50 % B. 1.1 % C. 5.0 % D. 10.5. %

73. The densities of water and nitrous acid are both 1.00 g/mL. The K_a for the acid is:

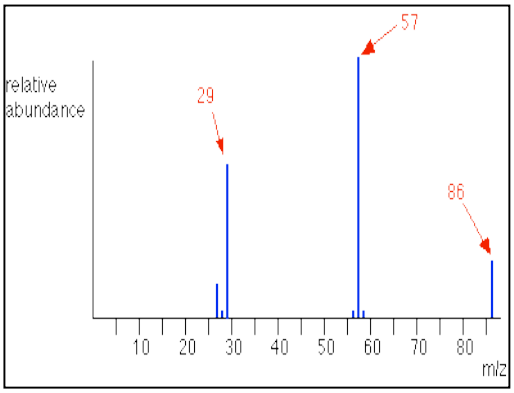
A. 3.78×10^{-6} B. 1.84×10^{-5} C. 3.92×10^{-4} D. 1.65×10^{-3}

74. A solution is 0.001 M in each of the metal cations: Ba^{2+}, Th^{4+}, Sc^{3+}, and Hg_2^{2+}. Solid NaF is slowly added to this solution. The order the fluorides precipitate is:

	1st	2nd	3rd	4th
A.	Hg_2^{2+}	Ba^{2+}	Sc^{3+}	Th^{4+}
B	Hg_2^{2+}	Ba^{2+}	Th^{4+}	Sc^{3+}
C.	Ba^{2+}	Sc^{3+}	Th^{4+}	Hg_2^{2}
D.	Ba^{2+}	Hg_2^{2+}	Sc^{3+}	Th^{4+}

Compound	K_{sp}
BaF_2	1.84×10^{-7}
ThF_4	5.0×10^{-29}
ScF_3	5.8×10^{-24}
Hg_2F_2	3.1×10^{-6}

75. A mass spectrometer fractures a molecule into pieces and separates the pieces by their individual masses. A mass spectrum is the record of the quantity of pieces of a particular mass and peak heights are proportional to the number of ions of each mass. The highest mass is the "parent" ion. To the right is a simplified mass spectrum of a compound that contains only C, H, and O. Use C = 12, H = 1, O = 16. Identify the molecule that gives the mass spectrum to the right.



A. $CH_3CH_2CH_2CH_2CH_2OH$
B. $CH_3CH_2COCH_2CH_3$
C. $CH_3COCH_2CH_2CH_3$
D. $CH_3CH_2CH_2CH_2CHO$

Use the following information for questions 76-78: Nernst Equation is: $E = E° - 0.0592/n \log Q$

Standard Reduction Potentials in Aqueous Solution at 298 K	E° (Volts)
$Au^{3+}(aq) + 3e^- \leftrightarrows Au(s)$	+1.50 V
$[AuCl_4]^-(aq) + 3\,e^- \leftrightarrows Au(s) + 4\,Cl^-(aq)$	+1.00 V
$Au^+(aq) + e^- \leftrightarrows Au(s)$	+1.83 V
$NO_3^-(aq) + 4H^+(aq) + 3e^- \leftrightarrows NO(g) + 2H_2O(l)$	+0.96 V
$2H^+(aq) + 2e^- \leftrightarrows H_2(g)$	+0.00 V

76. Using the cell potentials above, K_f for the formation of the $AuCl_4^-$ complex is:

A. 4.6×10^{-26} B. 2.8×10^{8} C. 1.0×10^{11} D. 2.3×10^{25}

77. Students should know that since gold is below $H^+(aq)$ in the activity series, it will not dissolve in acid. Which of the following **standard** cell reactions are spontaneous?

I. Dissolving gold in $HCl(aq)$, given that the $AuCl_4^-$ complex forms.
II. Dissolving gold in $HNO_3(aq)$, given that $NO_3^-(aq)$ is the oxidizing agent.
III. Dissolving gold in aqua regia from mixture of $HCl(aq)$ and $HNO_3(aq)$ in their standard states, given that $NO_3^-(aq)$ is the oxidizing agent and the $AuCl_4^-$ complex forms.

A. I, II, and III B. II and III only C. III only D. None are spontaneous.

78. Assuming that $AuCl_4^-$ and NO are in their standard states, i.e., 1.0 M and p_{NO} = 1 atm, and that $NO_3^-(aq)$ is the oxidizing agent and the $AuCl_4^-$ is the complex that forms, the electrochemical potential of dissolving gold in aqua regia with a mixture of 6.0 M HCl*(aq)* and 6.0 M $HNO_3(aq)$ is:

A. 0.098 V B. 0.18 V C. 0.28 V D. 0.37 V

79. The number of the following compounds that are soluble in water are:

$Zn(NO_3)_2$	AgI	$BaSO_4$	$CoCO_3$	LiOH

A. 0 B. 1 C. 2 D. 3

80. To determine the waters of hydration of a compound, a student heated a weighed sample of the hydrate in a weighed crucible. After heating and then cooling the crucible, the student weighed the sample to determine the water lost during the heating and then calculated the waters of hydration. Which of the following could explain why the student obtained the waters of hydration that were too high?

I. Overheating the sample.
II. While heating, losing some sample due to spattering.
III. Failure to heat the compound and crucible to a constant weight.

A. I only B. III only C. I and II only D. I, II, and III

81. Using the data to the right and the Born-Haber cycle, the heat of formation of KCl is:

A. -997 kJ B. -437 kJ C. -631 kJ D. +158 kJ

	ΔH°(kJ)
$K(s) \rightarrow K(g)$	89
$K(g) \rightarrow K^+(g) + e^-$	418
$Cl_2(g) \rightarrow 2\ Cl(g)$	244
$Cl(g) + e^- \rightarrow Cl^-g)$	-349
$KCl(s) \rightarrow K^+(g) + Cl^-(g)$	717

82. The Clausius-Clapeyron equation, $P = A \exp(-\Delta H_{vap}/RT)$, is the mathematical model for vapor pressure increase as a function of temperature, but it also applies to any phase transition. Vapor pressures of ice at 268 K and 273 K are 2.965 torr and 4.560 torr respectively. (R = 8.314 J/mole·K) The heat of sublimation of ice is:

A. 22.8 kJ/mole B. 46.2 kJ/mole C. 52.4 kJ/mole D. 759 kJ/mole

83. A newly discovered exoplanet planet, Aragon, is mostly made of the mineral, aragonite, $CaCO_3$, shown to the right. Aragon has an atmosphere of methane, CH_4, and carbon dioxide, CO_2, each at a pressure of 0.10 atm. The oceans are saturated with aragonite and have pH of 6.75 (1.78×10^{-7} M H^+). Using the following equilibra, the grams of calcium in a 2.00 L of Aragon seawater are: Use Ca^{2+} = 40.08 g/mole, $CaCO_3$ = 100.1 g/mole

$CaCO_3(s,\ aragonite) \leftrightarrows Ca^{2+}(aq) + CO_3^{2-}(aq)$	$K_{sp} = 6.0 \times 10^{-9}$
$CO_2(g) \leftrightarrows CO_2(aq)$	$K_{CO2} = 3.4 \times 10^{-2}$
$CO_2(aq) + H_2O(l) \leftrightarrows HCO_3^-(aq) + H^+(aq)$	$K_{a1} = 4.4 \times 10^{-7}$
$HCO_3^-(aq) \leftrightarrows CO_3^{2-}(aq) + H^+(aq)$	$K_{a2} = 4.7 \times 10^{-11}$

A. 0.22 g B. 0.27 g C. 3.70 g D. 18.5 g

84. Classify each 0.01 M aqueous solution below as acidic, basic, or neutral.

CH_3OH	NH_4NO_3	NaF	$Fe_2(SO_4)_3$	$KClO_4$

	Acidic	Basic	Neutral
A.	2	1	2
B.	1	3	1
C.	2	2	1
D.	1	2	2

85. *The Man in the Vat Problem:* Long ago a workman in a dye factory fell into a vat containing hot sulfuric acid and nitric acid. He was completely dissolved! Since nobody witnessed the accident, it was necessary to prove that he fell into the vat so that the widow could collect the insurance money. The man weighed 70 kg and the human body contains 6.3 ppt (parts per thousand) phosphorus. The acid in the vat was analyzed to see if it contained a dissolved human. The vat contained 8.00×10^3 L of liquid and a 100. mL sample was analyzed. If the man fell into the vat, the expected quantity of phosphorus in the 100. mL sample would be:

A. 5.5 mg B. 55 mg C. 0.875 g D. 5.04 g

A Recent Update: Gotti Neighbor's 'Acid Bath' Dip

US federal prosecutors have claimed that a man who vanished 29 years ago was killed, and his body was dissolved in acid on the orders of a notorious former crime boss, John Gotti. Now, if the Feds only knew some chemistry…!

Former crime boss John Gotti died in prison in 2002

86.

K_{sp} for Ag_2S	6×10^{-51}
K_{a1} for H_2S	1×10^{-7}
K_{a2} for H_2S	1×10^{-19}
K_f for $AgCl_2^-$	1×10^{5}

Using the values listed in the table, find the equilibrium constant for:

$$Ag_2S(s) + 4\ Cl^-(aq) + 2\ H^+(aq) \leftrightarrows 2\ AgCl_2^-(aq) + H_2S(aq)$$

A. 6×10^{-72} B. 6×10^{-67} C. 6×10^{-22} D. 6×10^{-15}

78. The order of molecular orbital (MO) energies in B_2, C_2, and N_2 ($\sigma_{2p} > \pi_{2p}$), is different from the order in O_2, F_2, and Ne_2 ($\sigma_{2p} < \pi_{2p}$), because of:

A. less effective overlap of p orbitals in O_2, F_2, and Ne_2.
B. less effective overlap of p orbitals in B_2, C_2, and N_2.
C. greater 2s-2p interaction in O_2, F_2, and Ne_2.
D. greater 2s-2p interaction in B_2, C_2, and N_2.

79. A buffer solution of formic acid and sodium formate has a pH = 3.70. After the addition of 0.015 moles of $[H^+]$, the pH decreases by 0.12. The initial molarity of the formic acid, pK_a (HCOOH) = 3.74, is:

A. 0.084 M B. 0.105 M C. 0.115 M D. 0.210 M

72) Calculate ΔG_{rxn} at 298 K under the conditions shown below for the following reaction.

$2\ Hg(g) + O_2(g) \rightarrow 2\ HgO(s)$ $\Delta G° = -180.8$ kJ

$P(Hg) = 0.025$ atm, $P(O_2) = 0.037$ atm

A) +207 kJ
B) -154.4 kJ
C) -26.5 kJ
D) -164 kJ
E) +60.7 kJ
Answer: B
Diff: 4 Page Ref: 17.8

73) Calculate ΔG_{rxn} at 298 K under the conditions shown below for the following reaction.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ $\Delta G° = +131.1$ kJ

$P(CO_2) = 0.033$ atm

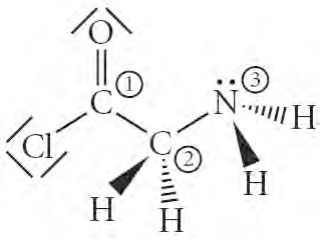
A) -49.3 kJ
B) -8.32 kJ
C) +122.6 kJ
D) +39.7 kJ
E) +43.3 kJ
Answer: C
Diff: 4 Page Ref: 17.8

43) A fishing boat accidentally spills 3.0 barrels of diesel oil into the ocean. Each barrel contains 42 gallons. If the oil film on the ocean is 2.5×10^2 nm thick, how many square meters will the oil slick cover?
A) $1.9 \times 10^{-3}\ m^2$
B) $1.9 \times 10^6\ m^2$
C) $1.9 \times 10^7\ m^2$
D) none of these
Answer: B
Diff: 5 Page Ref: 1.8

80)

Answer: D
Diff: 4 Page Ref: 10.8

19) Consider the molecule below. Determine the molecular geometry at each of the 3 labeled atoms.



A) 1=trigonal planar, 2=tetrahedral, 3=trigonal pyramidal
B) 1=tetrahedral, 2=tetrahedral, 3=tetrahedral
C) 1=trigonal planar, 2=tetrahedral, 3=tetrahedral
D) 1=tetrahedral, 2=tetrahedral, 3=trigonal planar
E) 1=trigonal planar, 2=trigonal pyramidal, 3=trigonal pyramidal
Answer: A

Diff: 4 Page Ref: 10.4