2015

NESACS Avery A. Ashdown High School Chemistry Examination Contest

Confidential

Identification Sheet

Test Number_____

Full Name_____
(Print) Last Name First Name Middle Initial

Home Address_____

Home Town, State & Zip_____

High School_____

Name of Local Newspaper_____

Name of Chemistry Teacher_____

Year of Graduation_____ **Home Phone**_____

e-mail_____

Number of Years of Chemistry (including this year)_____

Circle:

Have you taken the Ashdown exam in a previous year? **Yes** **No**

If so, were you a prize winner? **Yes** **No**

If you qualify, will you take the next Olympiad exam? **Yes** **No**
(Must be U.S. Citizen or Green Card holder)

Rules for the Examination

- There are 85 questions, and the exam will last 100 minutes.
- Absolutely **NO** cell phones, beepers or electronic messaging devices may be used in the test room. Any such devices that are used will be interpreted as cheating, and the user will be disqualified.
- **NO** cell phones, iPads or other devices which can communicate with the internet or with others may be used. Use of such devices will be interpreted as cheating and the user will be disqualified.
- When the proctor announced that time is up, you must **immediately** stop and turn in your bubble sheet.
- If you bring any books, papers, backpacks, etc. into the test room, deposit them against a wall.
- The only items allowed within your reach during the test are calculators, the exam, the bubble sheet, pencils, and erasers.
- ANY kind of calculator may be used as long as it is **only** a calculator. If you are using a graphing calculator, clear its memory **now**.
- ANY talking between students once the exam has begun will be interpreted as cheating, and all parties will be disqualified.
- Once the examination begins, you will not be allowed to leave the room.
- Students must remain seated during the exam. Once a student stands up, their exam must be turned in without any modifications.
- Nassiff's Test Taking Skill App: Cycle through the exam. Some questions are easier than others and the easy ones are scattered throughout. Do the easy stuff first and don't get stuck on the hard ones. Time is not your friend!

DIRECTIONS

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

  NAME__Your_Name___

  SUBJECT__School_____

  PERIOD_____DATE_____Test Number____

- 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 sheets 1, 2, and 3, the periodic table.

- 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.

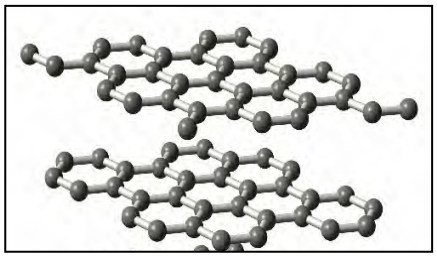
- Prize winners and qualifiers will be notified within 3 days or sooner.

- If you wish to continue as a qualifier for the U.S. Chemistry Olympiad, make sure you have filled out the official form.

- After the exam and after you have examined the answer key and if you feel that the answer key is incorrect, you have 72 hours to contact me for an appeal. My email is: nassiff@bpsk12.org
  Your appeal **must** include your justification.

- Good luck!

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



   A. charcoal
   B. diamond
   C. Bucky ball
   D. graphite

2. An atom with more electrons than protons is called:

   A. an anion
   B. a cation
   C. a molecule
   D. an isotope

3. Symbol to the right that represents the primary professional organization for chemists is:

   A. American Cancer Society
   B. Army Community Service
   C. Australian Cinematographers Society
   D. American Chemical Society

4. Discovered by French chemist Barnard Courtois in 1811 from seaweed ash, this element's name comes from the Greek word for violet, which happens to be the color of its gas. It turns blue in starch.

   A. selenium
   B. bromine
   C. iodine
   D. phosphorus

5. The chemical substance sometimes referred to as the "universal solvent" is:

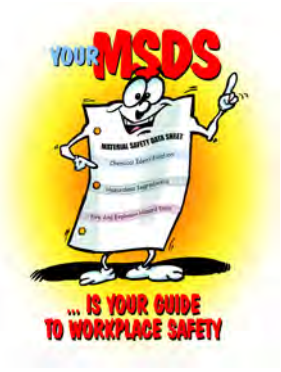
   A. ethyl alcohol
   B. water
   C. benzene
   D. hydrochloric acid

6. A common laboratory reaction performed in a high school laboratory is dissolving of copper metal in concentrated nitric acid, resulting in a blue beautiful solution of copper (II) nitrate. Balance the equation below to the smallest whole number coefficients and select the answer.

$$\_\_\_\_\_\ Cu(s) + \_\_\_\_\_\ HNO_3(aq) \rightarrow \_\_\_\_\_\ Cu(NO_3)_2(aq) + \_\_\_\_\_ NO(g) + \_\_\_\_\_\ H_2O(l)$$

   A. 15
   B. 20
   C. 30
   D. 40

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

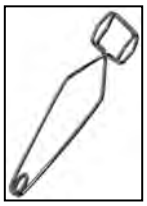


   A. Health hazards
   B. Precautions for Safe Handling and Use
   C. Fire and Explosion Hazard Data
   D. All of the above

8. The ion that will produce pale/apple green color in a flame test is:

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

9. 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(n):

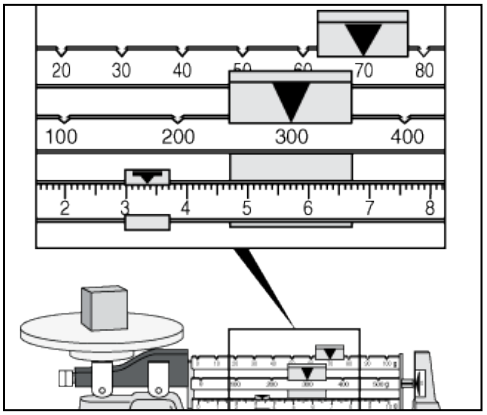


   A. test tube holder
   B. Erlenmeyer flask holder
   C. hot glass holder
   D. thingamajig to hold hot glassware

10. The element that has a melting point of 842 °C, a density of 1.55 grams/cm^3, an electronegativity of 1.00, an atomic radius of 197 pm, an electron affinity of 2.37 kJ/mole and a first ionization energy of 590 kJ/mole is

    A. Si
    B. Ca
    C. I
    D. B

11. The mass measured in grams by the balance to the left with the correct number of significant figures is:



    A. 373 g
    B. 373.3 g
    C. 373.35 g
    D. 373.350 g

12. Which sample has the most N atoms: $N_o = 6.02 \times 10^{23}$, N = 14.0, H = 1.01, O = 16.0, C = 12.0, and Ca = 40.1

    A. 1.00×10^{23} molecules of nitroglycerine, $C_3H_5N_3O_9$
    B. 0.400 moles of urea, CH_4N_2O
    C. 34.5 grams of NO_2
    D. 49.4 grams of Ca_3N_2

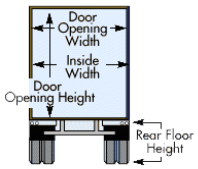
13. The equation for the standard heat of formation, ΔH_f^o, for $Fe(OH)_3(s)$ is:

    A. $2\ Fe(s) + 6\ H_2O(g) \rightarrow 2\ Fe(OH)_3(s) + 3\ H_2(g)$
    B. $Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$
    C. $Fe(s) + 3/2\ H_2(g) + 3/2\ O_2(g) \rightarrow Fe(OH)_3(s)$
    D. $2\ Fe(s) + 3\ H_2(g) + 3\ O_2(g) \rightarrow 2\ Fe(OH)_3(s)$

14. The electron geometry, molecular geometry, and hybridization for IF_4^- are:

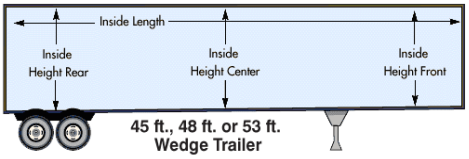
	Electron geometry	Molecular geometry	Hybridization
A.	tetrahedral	tetrahedral	sp^3
B.	trigonal pyramidal	seesaw	dsp^2
C.	trigonal pyramidal	square pyramid	dsp^2
D.	octahedral	square planar	d^2sp^3

15. You have won the Ashdown lottery and get a 45-foot semi-trailer full of $1 bills. Assuming you can pack the trailer with dollar bills with no loss of volume, how much did you win? 1 foot = 12 inches, 1 inch = 2.54 cm



A. $4.80 million
B. $12.2 million
C. $78.6 million
D. $624 million

	Dimensions	
	Trailer	Dollar Bill
Length	44 ft. 1½ in.	15.60 cm.
Width	93.0 in.	6.629 cm.
Height	110 in.	0.01092 cm.



16. Use the data to the right to find the formula for $Al_2(SO_4)_3 \cdot x\ H_2O$. $Al_2(SO_4)_3$ = 342.15 g/mole, H_2O = 18.01 g/mole

Mass of hydrate	3.332 grams
Mass of anhydride	1.711 grams

A. $Al_2(SO_4)_3 \cdot 3\ H_2O$
B. $Al_2(SO_4)_3 \cdot 6\ H_2O$
C. $Al_2(SO_4)_3 \cdot 12\ H_2O$
D. $Al_2(SO_4)_3 \cdot 18\ H_2O$

17. The empirical formula for an unknown compound composed of 19.15% potassium, 47.04% carbon, 2.47% hydrogen and 31.33% oxygen is: K = 39.1, O = 16.0, C = 12.0, H = 1.01

A. $KC_2H_3O_2$
B. $K_2C_6H_5O_4$
C. $KC_6H_5O_3$
D. $KC_8H_5O_4$

18. A current of 15.0 amperes is applied to aqueous solution $Al(NO_3)_3$ for 2.00 hours. The grams of Al metal plated are: (1 Faraday = 96,500 coulombs/mole, Al = 27.0 g/mole)

A. 0.00 g
B. 8.04 g
C. 10.1 g
D. 30.2 g

19. A sample of P-32 decays 5.0% daily. The half-life of P-32 is:

A. 4.32 days
B. 13.5 days
C. 28.0 days
D. 324 days

20. The correct number of names in the table to the right for the given formulas is:

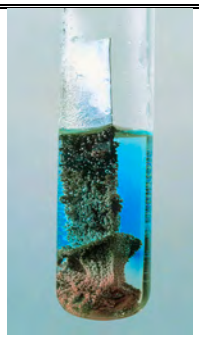
Formula	Name
K_2O	dipotassium monoxide
C_4H_{10}	propane
$CuSO_4$	copper carbonate
HOCl	hydrochloric acid

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

Use the following figures below to answer questions 21-24. Chemistry teachers love to give demos that excite students, and chemistry students observe many memorable reactions when doing labs. Identify the following four laboratories involving Zn and Cu from the images below:


A.


B.


C.

D.

21. Cu/Zn solution.

22. Cu metal in 6M nitric acid.

23. Zn in 3M hydrochloric acid.

24. Zn metal in 1M copper sulfate.

Formula	Molar Mass
$C_2H_4Cl_2$	98.96
Cl_2	70.91
O_2	32.00
C_2Cl_4	165.83

Use the following balanced equation to answer questions 25-27.

Tetrachloroethane, C_2Cl_4, often called perchloroethylene (perc), is a colorless liquid used in dry cleaning and can be made by the following balanced reaction:

$$8\ C_2H_4Cl_2(l) + 6\ Cl_2(g) + 7\ O_2(g) \rightarrow 4\ C_2HCl_3(l) + 4\ C_2Cl_4(l) + 14\ H_2O(l)$$

In an experiment involving this reaction, 50.0 grams of $C_2H_4Cl_2$ reacted with 36.0 grams of Cl_2 and 16.0 g of O_2.

25. Assuming a theoretical yield, the grams of C_2Cl_4 formed are:

A. 41.9 g
B. 42.1 g
C. 47.4 g
D. 56.1 g

26. Assuming a theoretical yield, the amount of excess reactants remaining after the reaction is:

A. 11.0 g left
B. 27.3 g left
C. 54.6 g left
D. 61.1 g left

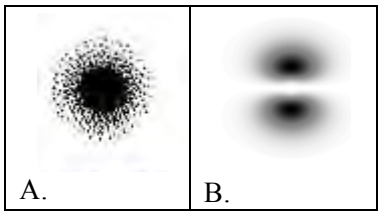
27. The student only obtained 17.5 grams of C_2Cl_4. Thus, the % yield was:

A. 31.2%
B. 36.9%
C. 41.6%
D. 41.8%

28. Which of the following is **not** evidence for the "big bang" theory is:

    A. Red shift spectra of galaxies.
    B. The abundance of helium in the universe
    C. Cosmic microwave background radiation.
    D. All of the above are evidence for the "big bang" theory.

29. In order to change the orbital shown in A to the orbital shown in B, an electron would have to



    A. reverse its spin.
    B. absorb energy.
    C. emit energy.
    D. be removed from the atom.

Use the following for questions 30-33. A 1.00 mole sample of CO_2, molar mass of 44.01 g/mole, occupies 0.200 liters at 27 ºC. R =0.08206 L • atm/ mole • K.

30. Using the ideal gas law, the pressure of the CO_2 is:

    A. 11.1 atm
    B. 112 atm
    C. 123 atm
    D. 542 atm

31. The actual pressure of CO_2 using van der Waals equation, shown to the right, is: For CO_2, a = 3.592 atm $L^2/mole^2$ and b = 0.04267 L/mole

$$\left[P + a\left(\frac{n}{V}\right)^2\right]\left(\frac{V}{n} - b\right) = RT$$

    A. 52.6 atm
    B. 66.7 atm
    C. 89.9 atm
    D. 156 atm

32. From the ideal gas law, the pressure of the CO_2 at 0.0500 L is 492 atm. Use the van der Waals equation and the constants found in #31 and calculate the pressure at 0.0500 L.

    A. 265 atm
    B. 1170 atm
    C. 1620 atm
    D. 1920 atm

33. The van der Waal's equation accounts for deviations of gases from ideal behavior. Examine the following statements about the two parameters, *a* and *b,* used in this equation and select all the true statements.

    I. Parameter *a* accounts for weak attractive forces between the molecules.
    II. Parameter *b* accounts for the sizes of the molecules.
    III. The higher pressure from ideal predicted at 0.0500 L is mostly due to its large value of *a*.

    A. III is true.
    B. II and III are true.
    C. I and II are true.
    D. I, II, and III are true

34. If you do not understand a direction or part of a lab procedure, you should

A. figure it out as you do the lab.
B. try several methods until something works.
C. skip it and go on to the next part.
D. ask the teacher before proceeding.

35. For the overall reaction: $4\ HBr + O_2 \rightarrow 2\ H_2O + 2\ Br_2$
The following mechanism to the right was proposed.
The equation for step 2 is:

Step 1	$HBr + O_2 \rightarrow HOOBr$
Step 2	? ? ? ?
Step 3	$HBr + HOBr \rightarrow H_2O + Br_2$

A. $HBr + HOOBr \rightarrow HOBr + H_2O + Br_2$
B. $2\ HBr + 3\ HOBr \rightarrow HOOBr + H_2O + Br_2$
C. $2\ HBr + HOOBr + HOBr \rightarrow 3\ H_2O + 2\ Br_2$
D. $2\ HBr + HOOBr \rightarrow HOBr + H_2O + Br_2$

36. Which statement concerning the autoionization of water is false?

$$2\ H_2O(l) \leftrightarrows H_3O^+(aq) + OH^-(aq)$$

A. This is an acid base reaction according to the Bronsted-Lowry theory
B. Water is amphiprotic.
C. H_3O^+ and OH- are a conjugate acid-base pair.
D. A H_2O molecule may react as an acid by donating a proton.

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

I.

II .

III.

IV.

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

38. Classify the 0.01 M aqueous solutions shown below as acidic, basic, or neutral and select the correct option.

CH_3OH	NH_4NO_3	NaF	$Al_2(SO_4)_3$	Na_2SO_4

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

Use the following for questions 39 and 40. 1-Propanol has the following vapor pressures:

Temp (◦C)	P (torr)
80	376
100	843
97.3	760

Clausius-Clapeyron Equation with R = 8.314 J/mole·K is:

$$\ln\left(\frac{P_1}{P_2}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

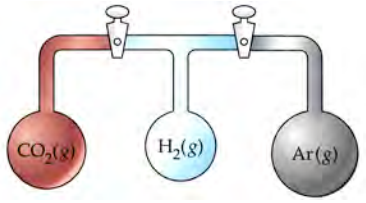
39. The enthalpy of vaporization, ΔH_{vap}, is:

A. 5320 J
B. 19.4 kJ
C. 44.2 kJ
D. 48.2 kJ

40. The total entropy change, ΔS, when 100 g of 1-propanol (60.09 g/mole) is vaporized at the boiling point is:

A. 120 J
B. 199 J
C. 461 J
D. 767 J

Use the following for questions 41 and 42. The apparatus shown to the right consists of three bulbs connected by stopcocks. The contents of the bulbs are shown in the table below.



41. What is the pressure inside the system when the stopcocks are opened? Assume that the lines connecting the bulbs have zero volume and that the temperature remains constant.

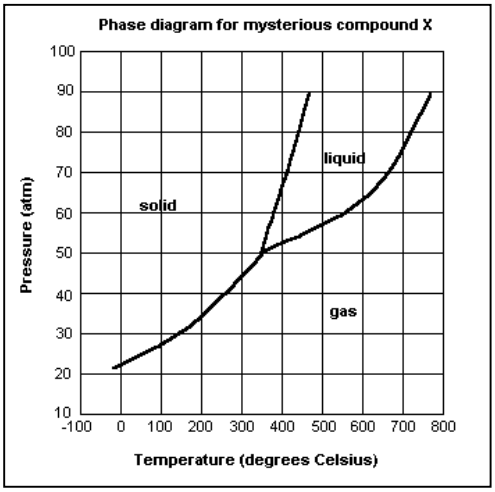
A. 0.669 atm
B. 0.956 atm
C. 1.45 atm
D. 1.50 atm

	Left Bulb	Center Bulb	Right Bulb
Gas	CO_2	H_2	Ar
P	2.15 atm	1.00 atm	1.15 atm
V	1.50 L	1.00 L	2.00 L

42. The mole fraction of H_2 is:

A. 0.153
B. 0.223
C. 0.332
D. 0.376

43. The phase diagram for compound X is shown to the right. If you had a bottle of compound X in your book bag, what state would it be in?



A. solid
B. liquid
C. gas
D. solid and gas

44. The correct answer for the calculation below with values that are obtained from scientific measurement is:

$$3.969 - 1.800 + 8.26 \times 10^{-3}$$

A. 2.178
B. 2.177
C. 2.1773
D. 2.17726

Use the following for questions 45-48 for the reaction: $2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$
R = 8.314 J/ mole K

	$CO_2(g)$	$CO(g)$
ΔG_o^f	-394. kJ/mole	-137. kJ/mole
ΔH_o^f	-394. kJ/mole	-111. kJ/mole

45. ΔG^o for the reaction is:

A. -257 kJ
B. -514 kJ
C. -1010 kJ
D. -1060 kJ

46. ΔS^o for the reaction:

A. 0.17 J
B. -95 J
C. -174 J
D. 1720 J

47. The equilibrium constant at 100 ºC is:

A. 3.5×10^{-68}
B. 2.9×10^{67}
C. 9.6×10^{71}
D. 1.3×10^{90}

48. ΔG at 0 ºC when the partial pressures of $P_{CO2} = 1.00$ atm, and $P_{O2} = P_{CO} = 5.00$ atm:

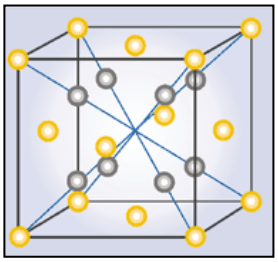
A. -521 kJ
B. -525 kJ
C. -529 kJ
D. 1020 kJ

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

$CuSO_4$	$PbBr_2$	$CaSO_4$	$(NH_4)_2CO_3$	LiOH

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

50. What is the empirical formula of the unit cell shown to the right?
The light spheres are M and dark spheres are X.



A. MX
B. MX_2
C. M_2X_3
D. MX_3

Standard Enthalpy of Formation	
$\Delta H_f^o(NH_3(g))$	-46.2 kJ
Bond Energies (kJ/mole)	
H-H	436
N≡N	941
N=N	418
N-N	163

51. From the reaction below and the table to the right, the average N-H bond energy is:

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

A. 229 kJ/mole
B. 272 kJ/mole
C. 359 kJ/mole
D. 390 kJ/mole

52. A sample contains both KBr and KI in unknown quantities. If a 5.00 gram sample contains 1.50 grams of potassium, what are the percentages by mass of KBr and KI in the sample? K = 39.10, Br = 79.90, I = 126.90

A. 30.0% KBr, 70.0 %KI
B. 58.2% KBr, 41.8% KI
C. 69.3% KBr, 30.7% KI
D. 78.0% KBr, 22.0% KI

53. Which of the following is optically active, has a molecular formula of C_7H_{16} and has the correct IUPAC name?

A. 2-methylhexane
B. 3-methylhexane
C. 2-ethylpentane
D. 3-methylheptane

Use the information in the table to answer questions 54-56.

Reaction	Reduction Potentials
$I_2(s) + 2e^- \leftrightarrows 2I^-$	$E_o = 0.535$ V
$I_2(aq) + 2e^- \leftrightarrows 2I^-$	$E_o = 0.620$ V
$I_3^- + 2e^- \leftrightarrows 3I^-$	$E_o = 0.535$ V

$$E = E^\circ - \frac{0.05916}{n} \log Q$$

54. The potential for the reaction below is

$$I_2(aq) + I^- \leftrightarrows I_3^-$$

A. 0 V
B. 0.085 V
C. 1.070 V
D. 1.155 V

55. The equilibrium constant for the above reaction is

A. 2.05
B. 17.8
C. 27.3
D. 747

56. The solubility in g/L of $I_2(s)$ in water, $I_2(s) \leftrightarrows I_2(aq)$, is: I = 126.9 g/mole

A. 0.17 g/L
B. 0.34 g/L
C. 4.64 g/L
D. 9.3 g/L

Use the following for questions 57-60. A sample of $N_2O_4(g)$ undergoes a temperature-dependent equilibrium to form $NO_2(g)$ as shown in the reaction below. An evacuated reaction bulb was filled with argon gas in the conditions shown in the table. Assume the gases are ideal. Ar = 39.948 g/mole, R = 0.08206 L atm/ mole K = 8.314 J K^{-1} $mole^{-1}$, N_2O_4 = 92.011 g/mole, NO_2 = 46.0055 g/mole

Temperature	20.0 ºC
Pressure	1.000 atm
Mass flask	98.89900 g
Mass flask + Ar	99.36683 g

$$N_2O_4(g) \leftrightarrows 2\ NO_2(g)$$

57. What is the volume of the flask?

A. 1.922 x 10^{-2} L
B. 0.2816 L
C. 0.4602 L
D. 0.7678 L

58. The bulb was evacuated, filled with N_2O_4, and allowed to reach equilibrium at 57.0 ºC and 1.000 atm. The bulb had a mass of 99.50500 g. The average molar mass of the equilibrium gas mixture is

A. 35.66
B. 46.06
C. 51.74
D. 58.28

59. The value of the equilibrium, K_p, at 57 ºC is

A. 0.491
B. 1.11
C. 2.02
D. 3.23

60. K_p at -23 ºC is 2.50 x 10^{-3}. The value of ΔH^o for this reaction is

A. 0.704 kJ
B. 48.5 kJ
C. 57.4 kJ
D. 70.1 kJ

61. The Mars Rover brought back a "mystery metal" that it crystallizes in a face centered cubic lattice with cell edge **a** = 508.42 pm and its density is 11.724 g/cm^3. 1 pm = 10^{-12} m What is the metal? N_o = 6.022 x 10^{23}

A. Fe
B. Os
C. Pb
D. Th

62. According to the Heisenberg Uncertainty Principle, $\Delta p \Delta x \geq \frac{h}{4\pi}$, if the uncertainty in the speed of an electron is 3.5 x 10^3 m/s, the uncertainty in its position in meters is at least:
$m_{electron}$ = 9.11 x 10^{-31} kg, h = 6.63 x 10^{-34} J·s

A. 1.5 x 10^{-38} m
B. 1.7 x 10^{-8} m
C. 6.6 x 10^{-8} m
D. 0.20 m

63. The first ionization energy of beryllium is more than that of boron because:

A. Beryllium has filled s-orbital.
B. Beryllium has filled a half-filled s-orbital.
C. Boron atom is smaller in size than the beryllium atom.
D. Boron is more electronegative than beryllium.

Use the following for questions 64 and 65. Due to the recent snowstorms and because of your acumen in science, you were asked to determine the kilograms of rock salt (NaCl) needed to melt the ice on the school's sidewalks and outside waiting areas so that you and your fellow classmates may be safe as you walk to your car or bus. It is estimated that the school's side walks and outside areas are 50.0 m x 10.0 m and the ice is 5.0 mm thick. The density of ice is 0.934 g/cm^3.

64. Approximately how many kg of ice are there?

A. 2.35 kg
B. 2340 kg
C. 2500 kg
D. 23500 kg

65. It was requested that ice solution be -5.00 ºC. K_f for water is 1.86 ºC/m. How many kg of NaCl are required? The molar mass of NaCl is 58.44 g/mole.

A. 183 kg
B. 196 kg
C. 366 kg
D. 392 kg

66. In an empty flask, $COCl_{2(g)}$ is introduced at 1.0 atm pressure where it dissociates according to the reaction below until equilibrium is reached:

$$2\ COCl_{2(g)} \leftrightarrows C_{graphite} + CO_{2(g)} + 2\ Cl_{2(g)}$$

If **x** represents the partial pressure of $CO_{2(g)}$ at equilibrium, the value of K_p is

A. $\frac{x \cdot 2x^2}{(1.0 - 2x)^2}$
B. $\frac{x \cdot x \cdot (2x)^2}{(1.0 - 2x^2)}$
C. $\frac{x \cdot (2x)^2}{(1.0 - 2x)^2}$
D. $\frac{x \cdot (2x)^2}{(1.0 - x)^2}$

67. The reaction, $2\mathbf{A} + 2\mathbf{B} \rightarrow \mathbf{C} + \mathbf{D}$, proceeds by the following proposed mechanism:

Step 1	$2\ \mathbf{A} \leftrightarrows \mathbf{A_2}$	equilibrium
Step 2	$\mathbf{A_2} + \mathbf{B} \rightarrow \mathbf{X} + \mathbf{C}$	rate determining
Step 3	$\mathbf{X} + \mathbf{B} \rightarrow \mathbf{D}$	rapid

The rate equation for the reaction is

A. rate = k[A][B]
B. rate = $k[A]^2[B]^2$
C. $\text{rate} = k\dfrac{[A]^2[B]}{[C][D]}$
D. rate = $k[A]^2[B]$

68. The following molar absorptivities, ε_o in $M^{-1}cm^{-1}$, pertaining to the analysis of compounds A and B at 272 nm and 327 nm, are shown to the right. A mixture of A and B in a 1.00 cm cell had an absorption of 0.960 at 272 nm and 0.560 at 327 nm. The concentrations of A and B are:

	ε_o at 272 nm	ε_o at 327 nm
A	16500	4000
B	3870	6420

A. [A] = 4.42×10^{-5} M, [B] = 5.97×10^{-5} M
B. [A] = 4.34×10^{-5} M, [B] = 6.10×10^{-5} M
C. [A] = 3.23×10^{-5} M, [B] = 4.55×10^{-5} M
D. [A] = 1.41×10^{-4} M, [B] = 2.70×10^{-6} M

Use the following for questions 69 and 70. Solution A contains 0.0500 M HF. Solution B contains 0.0500 M ammonia. $K_a(HF) = 6.8 \times 10^{-4}$, $K_b(NH_3) = 1.8 \times 10^{-5}$, $K_w = 1.0 \times 10^{-14}$

69. What is the equilibrium constant, K, for the reaction when the two solutions are mixed?

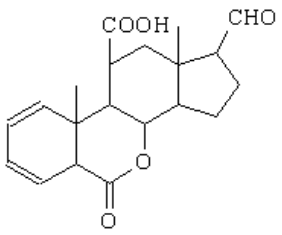
$$HF(aq) + NH_3(aq) \leftrightarrows F^-(aq) + NH_4^+(aq)$$

A. 3.9×10^{-15}
B. 1.2×10^{-8}
C. 39.0
D. 1.2×10^{6}

70. What is the pH of a solution that has 20.0 mL of 0.0500 M HF mixed with 15.0 mL of 0.0500 M NH_3?

A. 2.69
B. 3.65
C. 4.28
D. 5.23

71. This compound to the right has the following functional groups:



A. ketone, alkene, carboxylic acid, ester
B. alkyne, ester, carboxylic acid, aldehyde
C. carboxylic acid, alkene, ketone, ester
D. ester, aldehyde, carboxylic acid, alkene

72. From the half reactions in the table, the solubility product, K_{sp}, for $Mg(OH)_2$ is:

$Mg^{2+} + 2e^- \leftrightarrows Mg(s)$	$E_o = -2.36$ V
$Mg(OH)_2(s) + 2e^- \leftrightarrows Mg(s) + 2OH^-$	$E_o = -2.69$ V

$$E = E^\circ - \frac{0.05916}{n} \log Q$$

A. 7.0×10^{-12}
B. 7.5×10^{-9}
C. 1.3×10^{-6}
D. 1.4×10^{-5}

73. A mixture contains only cyclohexane, C_6H_{12} (84.16 g/mole) and oxirane, C_2H_4O (44.05 g/mole). When 7.300 mg was analyzed by combustion analysis, 22.000 mg of CO_2 (44.01 g/mole) were produced. The % by weight of oxirane is

A. 10.8%
B. 18.2%
C. 21.5%
D. 40.1%

74. Approximately how many grams of potassium acid phthalate, KHP (204.233 g/mole), should be weighed into a flask to standardize ~0.10 M NaOH if you wish to titrate ~35 mL of the base for the titration?

A. 0.06 g
B. 0.66 g
C. 0.71 g
D. 0.83 g

75. Which of the following is false?

A. Valence bond (VB) theory and molecular orbital (MO) theory are as two different views of the same thing.
B. Molecular orbitals are generally more delocalized than hybridized atomic orbitals.
C. One of the shortcomings of the VB theory is the inability to account for paramagnetism in the O_2 molecule.
D. One of the shortcomings of the MO theory is the inability to account for the triple bond in the N_2 molecule.

76. A compound with a molar mass of 292.16 g/mole was dissolved in a 5.00-mL volumetric flask. A 1.00-mL aliquot was pipette into a 10.00-mL volumetric flask and diluted to the mark. The absorbance measured at 340 nm was 0.429 in a 1.000 cm cuvette. Molar absorptivity for this compound at 340 nm is $\varepsilon_{340} = 6130\ M^{-1}cm^{-1}$. How many milligrams of the compound were used to make the 5.00-mL solution

A. 0.700 mg
B. 1.02 mg
C. 1.40 mg
D. 2.04 mg

77. The resonance structure that gives the most accurate representation of the SCN^- anion is one which

A. the formal charge of S is -1, the formal charge of C is +2, and the formal charge of N is -2.
B. the formal charge of S is -1, the formal charge of C is 0, and the formal charge of N is 0.
C. the formal charge of S is 0, the formal charge of C is 0, and the formal charge of N is -1.
D. the formal charge of S is +1, the formal charge of C is 0, and the formal charge of N is -2.

78. At 25 ºC, the activation energy, E_a, for the decomposition of H_2O_2 is 75.3 kJ/mole. In the presence of the iodide ion catalyst, E_a = 56.5 kJ/mole. However, when catalyzed by the blood enzyme, catalase, E_a = 8.40 kJ/mol. If 1.0 seconds is required to collect 100 mL of oxygen when catalase is present, how long would it take to collect 100 mL of oxygen when iodide is used as a catalyst? R = 8.314 J/mole·K

A. 3.3 minutes
B. 6.7 days
C. 8.6 years
D. 1.0 million years

79. If a 0.10 M solution of a base has a pH = 9.71, what is the K_b for the base? $pK_w = 14.00$

$B + H_2O \leftrightarrows BH^+ + OH^-$

A. 2.8×10^{-18}
B. 5.0×10^{-10}
C. 2.6×10^{-8}
D. 5.0×10^{-5}

80. The planet Aragonose, composed mainly of the mineral aragonite ($CaCO_3$) (picture to the right) has an atmosphere containing CH_4 and CO_2, each at a pressure of 0.20 atm. The oceans are saturated with aragonite and have a pH of 6.5. Given the equilibra below, calculate how many grams of Ca per liter are in Aragonose sea water. Ca = 40.08 g/mole
Hint: Reverse the first reaction and see what adds up!

A. 0.11 g
B. 0.17 g
C. 0.39 g
D. 3.62 g

$CaCO_3(s,\ aragonite) \leftrightarrows Ca^{2+}(aq) + CO_3^{2-}(aq)$	$K_{sp} = 6.0 \times 10^{-9}$
$CO_2(g) \leftrightarrows CO_2(aq)$	$K_{CO2} = 3.4 \times 10^{-2}$
$CO_2(aq) + H_2O(l) \leftrightarrows HCO_3^-(aq) + H^+(aq)$	$K_1 = 4.4 \times 10^{-7}$
$HCO_3^-(aq) \leftrightarrows H^+(aq) + CO_3^{2-}(aq)$	$K_2 = 4.7 \times 10^{-11}$

Use the following for questions 81 and 82.

^1_1H	1.00782 amu
^4_2He	4.00260 amu
^0_1e	0.0005486 amu

81. The energy produced in the fusion of 1.00 gram of hydrogen in the following reaction is: 1 amu =1.6605×10^{-24} g, c = 2.998×10^8 m/s, N_o =6.0223×10^{23}

$$4\ {}^1_1H \rightarrow {}^4_2He + 2\ {}^0_1e$$

A. 6.20×10^8 kJ
B. 2.48×10^6 kJ
C. 6.90×10^6 kJ
D. 2.48×10^9 kJ

82. The enthalpy of combustion of propane (44.0 g/mole) gas is -2220 kJ/mole. How many kilograms of propane will be needed to produce the same amount of heat?

A. 1.23×10^4 kg
B. 4.91×10^4 kg
C. 4.91×10^7 kg
D. 1.23×10^{10} kg

83. A fluoride ion selective electrode is calibrated over a range of 0.10 to 10.0 ppm and found to have an intercept of 230 mV and a slope of -56.3 mV. A water sample containing an unknown F^- is analyzed by taking a 10.0 mL sample of water, a buffer, and diluting it to 250.0 mL in a volumetric flask. Using the calibrated electrode, the resulting solution measured 330 mV. What is the concentration of the fluoride in the original water sample?
Hint: $E = m \log [F^-] + b$

A. 0.017 ppm
B. 0.42 ppm
C. 0.94 ppm
D. 2.35 ppm

Molar Mass (g/mole)	
Mg	24.30
$MgCO_3$	84.31
Ca	40.08
$CaCO_3$	100.09
Ksp	
$MgCO_3$	6.82×10^{-6}
$CaCO_3$	6.00×10^{-9}

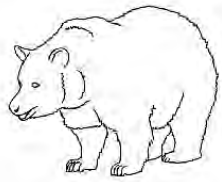
84. The Mg^{2+} and Ca^{2+} ions in hard water hinder soaps and detergents. Water softeners which use Na_2CO_3 are used to remove these ions. Suppose that hard water used to do laundry contains 75 ppm $CaCO_3$ and 55 ppm $MgCO_3$ by mass. What mass of Na_2CO_3 must be used to remove 90.0% of these ions from 10.0 L of laundry water?
Hint: ppm = mg/L

A. 15.9 g
B. 31.8 g
C. 51.6 g
D. 111 g

85. Chemists learn early on that "like dissolves like." Select the bear below that fits "like dissolves like."

Hint

A.


B.


C.


D.