Dougherty Valley • Honors Chemistry Name _____

Spring Final Exam Practice Test 3

Period _____ Date _____

- KEY

PRACTICE TEST

The following information may be helpful.

$D = \frac{m}{V}$	$K = °C + 273$	$\underline{M} = \frac{n}{V}$	$V_c \cdot \underline{M}_c = V_d \cdot \underline{M}_d$
$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$	$P \cdot V = n \cdot R \cdot T$	$R = 0.0821 \frac{L \cdot atm}{mol \cdot K}$	Molar Mass $= \frac{m}{n}$
$[H^+] \cdot [OH^-] = 1.0 \times 10^{-14}$	$pH + pOH = 14$	$pH = -\log[H^+]$	$pOH = -\log[OH^-]$
$A = a \cdot b \cdot c$	$\Delta H_{rxn} = \frac{q_{rxn}}{n_{rxn}}$	$[H^+] = 10^{-pH}$	$[OH^-] = 10^{-pOH}$
1 atm = 760 mmHg = 760 torr = 14.7 psi = 101.3 kPa		1 mole = 6.022×10^{23} particles = 22.4 L gas at STP	

Solubility Rules for Salts		
Always soluble:	• alkali ions, NH_4^+, NO_3^-, ClO_3^-, ClO_4^-, $C_2H_3O_2^-$, HCO_3^-	
Generally soluble:	• Cl^-, Br^-, I^-	Soluble except with Ag^+, Pb^{2+}, Hg_2^{2+}
	• F^-	Soluble except with Pb^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, Mg^{2+}
	• SO_4^{2-}	Soluble except with Pb^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}
Generally insoluble:	• O^{2-}, OH^-	Insoluble except with Ca^{2+}, Ba^{2+}, Sr^{2+}, alkali ions, NH_4^+
	• CO_3^{2-}, PO_4^{3-}, S^{2-}, SO_3^{2-}, CrO_4^{2-}, $C_2O_4^{2-}$	Insoluble except with alkali ions, NH_4^+
Strong Acids	HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_3$, $HClO_4$, HIO_4	
Gases that Form	→ H_2S (g)	→ H_2SO_3 (aq) → SO_2 (g) + H_2O (ℓ)
	→ H_2CO_3 (aq) → CO_2 (g) + H_2O (ℓ)	→ NH_4OH (aq) → NH_3 (g) + H_2O (ℓ)

Part 1: Multiple Choice. Select the answer choice that best completes the question.

1. Bonds between which of the following elements is expected to be most polar?
   (A) C–H
   (B) N–O
   (C) P–F
   (D) S–Br

2. Which type of bond is described as "a lattice of positive ions in a sea of electrons"?
   (A) covalent
   (B) hydrogen
   (C) ionic
   (D) metallic

3. The compound $(NH_4)_2CO_3$ contains how many atoms of hydrogen?
   (A) 2
   (B) 4
   (C) 6
   (D) 8

4. An unknown element X forms a salt with the formula XO_2. Which of the following could be X?
   (A) Al^{3+}
   (B) Ca^{2+}
   (C) Na^+
   (D) Sn^{4+}

5. Which of the following name is correctly paired with its formula?
   (A) Carbonate CO_3^{2-}
   (B) Chloride ClO_3^-
   (C) Ferric Fe^{2+}
   (D) Nitrate NO_2^-

6. Which one of the following is the correct formula for calcium phosphate?
   (A) $Ca_2(PO_4)_3$
   (B) $Ca_3(PO_4)_2$
   (C) $CaPO_4$
   (D) PO_4Ca_3

7. What is the name of the compound N_2O_3?
   (A) dinitride trioxide
   (B) dinitrogen trioxide
   (C) nitrate
   (D) nitrogen oxide

8. What is the percent of carbon in barium carbonate, $BaCO_3$ (molar mass = 197.3 g/mol)?
   (A) 3.04%
   (B) 6.09%
   (C) 14.0%
   (D) 20.0%

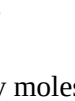
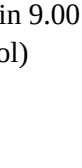
9. How many moles of hydrogen cyanide, HCN, are contained in 9.00 grams of HCN? (molar mass = 27.03 g/mol)
   (A) 0.333
   (B) 0.900
   (C) 1.00
   (D) 9.00

10. How many molecules are in 2.00×10^{-2} moles of carbon tetrachloride, CCl_4? (molar mass = 154 g/mol)
    (A) 1.20×10^{23}
    (B) 3.01×10^{23}
    (C) 6.02×10^{23}
    (D) 1.20×10^{22}

11. Which of the following describes the bonds in a molecule of ethyne, C_2H_2?
    (A) 1 double bond, 2 single bonds.
    (B) 1 triple bond, 2 single bonds.
    (C) 2 double bonds, 1 single bond.
    (D) 3 single bonds.

12. The total number of dots drawn in the Lewis structure of nitrogen, N_2, is
    (A) 5
    (B) 10
    (C) 14
    (D) 16

13. Which of the following is the correct Lewis Structure for carbon monoxide, CO?
    (A) 
    (B) 
    (C)
    (D) 

14. Which one of these molecules is polar?
    (A)
    (B) 
    (C) 
    (D) 

15. Which of the following is paired INCORRECTLY with the solid it forms?
    (A) Bronze – Metallic solid
    (B) CaO – Ionic solid
    (C) H_2O – Molecular solid
    (D) P_4O_{10} – Network covalent solid

16. An unknown solid has a melting point of 400°C and conducts electricity. Which of the following could be the solid?
    (A) Diamond, C
    (B) Salt, NaCl
    (C) Sugar, $C_6H_{12}O_6$
    (D) Zinc, Zn

17. Which of the following is expected for a sample of solid P_4O_{10}?
    (A) It is malleable.
    (B) It has a low melting point.
    (C) It conducts electricity when it is melted.
    (D) It is lustrous.

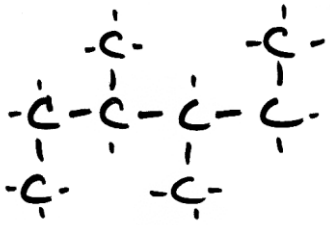
18. What intermolecular forces are present between molecules of HCl but not H_2?
    (A) Dipole-dipole interactions
    (B) Hydrogen bonding
    (C) Ionic bonds
    (D) London dispersion forces

19. Water molecules are attracted to each other with this type of intermolecular force.
(A) Covalent bonding
(B) Dipole-dipole interactions
(C) Hydrogen bonding
(D) London dispersion forces

20. Which of the following is expected do have the highest melting point?
(A) BH_3
(B) CH_4
(C) H_2
(D) NH_3

21. The general formula C_nH_{2n} describes the molecular composition of the hydrocarbon family known as the
(A) alkadienes
(B) alkanes
(C) alkenes
(D) alkynes

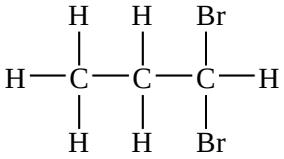
22. How many carbons make up the "parent chain" in the following molecule?



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

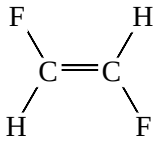
23. The number of isomers of bromopropane, C_3H_7Br, is
(A) 2
(B) 3
(C) 4
(D) 7

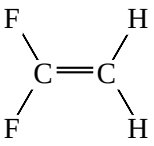
24. Which of the following is the correct name for the following compound:

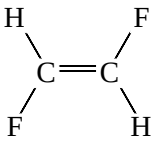


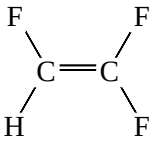
(A) 1,1-dibromobutane
(B) 1,1-dibromopropane
(C) 2-bromopropane
(D) 3,3-dibromopropane

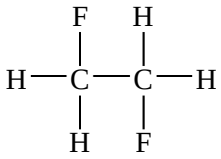
25. Which of the following is an isomer of the compound below:



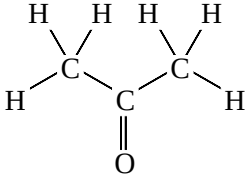
(A)


(B)


(C)


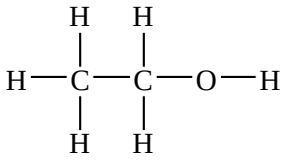
(D)


26. Which functional group is found in the following compound?



(A) Aldehyde
(B) Carboxylic Acid
(C) Ether
(D) Ketone

27. The structure of which compound is given below?



(A) Grain alcohol (ethanol)
(B) Isopropyl alcohol (2-propanol)
(C) Nail polish remover (acetone, or propanone)
(D) Vinegar (ethanoic acid)

28. Which set of coefficients balances the equation for the complete combustion of ethane, C_2H_6?
$\ldots C_2H_6\,(g) + \ldots O_2\,(g) \rightarrow \ldots CO_2\,(g) + \ldots H_2O\,(\ell)$
(A) 1,3,2,3
(B) 1,6,2,6
(C) 2,6,4,5
(D) 2,7,4,6

29. When the equation for the combustion of propene, C_3H_6, is balanced with the lowest whole-number coefficients, what is the coefficient of oxygen, O_2?
(A) 6
(B) 9
(C) 12
(D) 18

30. When an alcohol reacts with a carboxylic acid, which of the following is formed?
(A) A ketone
(B) An ester
(C) An ether
(D) CO_2

31. Which of the following compounds is expected to be soluble in water?
(A) $CaSO_4$
(B) FeS
(C) $PbCl_2$
(D) $SrBr_2$

32. Which of the following represents the dissociation of CaI_2 in solution?
(A) $CaI_2 \rightarrow Ca + I_2$
(B) $CaI_2 \rightarrow Ca^{2+} + 2\ I^-$
(C) $CaI_2 \rightarrow Ca^{2+} + I_2$
(D) CaI_2 is insoluble so it does not dissociate.

33. How many grams of sodium hydroxide pellets, NaOH, are required to prepare 50.0 mL of a 0.150 M solution? [molar mass NaOH = 40.0 g/mol]
(A) 0.300
(B) 2.00
(C) 3.00
(D) 200.

34. List the following solutions prepared with the same solute in order of increasing concentration:
I. 30.0 g solute in a 240 mL solution
II. 30.0 g solute in a 120 mL solution
III. 60.0 g solute in a 120 mL solution
(A) I < II < III
(B) II < I < III
(C) II < III <I
(D) III < II < I

35. A 100 mL sample of a solution with a concentration of 5.00 M is diluted to a new volume of 400 mL with distilled water. The new concentration will be
(A) 1.25 M
(B) 1.66 M
(C) 15.0 M
(D) 20.0 M

36. The acid $HClO_3$ is named:
(A) Chloric acid
(B) Hydrochloric acid
(C) Hydrogen chlorate
(D) Hydrogen chlorine trioxide

37. A solution tested with cabbage juice turns green. Which of the following could be its pH?
(A) 1
(B) 4
(C) 7
(D) 10

38. A substance that turns cabbage juice blue and slightly lights up a light bulb is a:
(A) strong acid
(B) strong base
(C) weak acid
(D) weak base

39. Which chemical is the conjugate base in the reaction?

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

(A) H_2O
(B) NH_3
(C) NH_4^+
(D) OH^-

40. If a solution has $[OH^-] = 1.0 \times 10^{-3}$ M, what is the pH?
(A) 3
(B) 7
(C) 11
(D) 14

41. An acid was neutralized by the following reaction:

$$NaOH + HCl \rightarrow NaCl + H_2O$$

This reaction would be classified as
(A) decomposition
(B) double replacement
(C) single replacement
(D) synthesis

42. $\ldots H_3PO_3 \rightarrow \ldots H_3PO_4 + \ldots PH_3$

When the equation above is balanced, the coefficient for H_3PO_4 is:
(A) 1
(B) 2
(C) 3
(D) 4

43. When solutions of potassium sulfate and calcium bromide are combined, which of the following precipitates?
(A) KBr
(B) CaS
(C) $CaSO_4$
(D) There is no precipitate.

44. Which of the following are products when magnesium metal is placed in hydrochloric acid?
(A) H
(B) H^+
(C) Mg
(D) $MgCl_2$

45. $Zn \rightarrow Zn^{2+} + 2e^-$

In the half reaction above:
(A) Zn is oxidized because it is gaining electrons.
(B) Zn is oxidized because it is losing electrons.
(C) Zn is reduced because it is gaining electrons.
(D) Zn is reduced because it is losing electrons.

46. The classic holiday demonstration, "Chemist's Tree," undergoes the reaction:

$$Cu + 2\ Ag^+ \rightarrow 2\ Ag + Cu^{2+}$$

The copper, Cu, is ____ electrons and being _____.
(A) gaining, oxidized
(B) gaining, reduced
(C) losing, oxidized
(D) losing, reduced

47. When we reacted $AgNO_3$ and K_2CrO_4 to form Ag_2CrO_4 and KNO_3, _____ was oxidized.
(A) chromate ion
(B) nitrate ion
(C) silver ion
(D) nothing (it wasn't a redox reaction)

48. What mass of sulfur dioxide, SO_2 (64.0 g/mol), is produced when 245 g of sulfuric acid, H_2SO_4 (98.0 g/mol) reacts completely with zinc metal according to the balanced equation below?

$$Zn + 2\ H_2SO_4 \rightarrow ZnSO_4 + SO_2 + 2\ H_2O$$

(A) 64.0 g
(B) 80.0 g
(C) 128 g
(D) 160 g

49. At STP, how many liters of oxygen gas react with 4.00 moles of PH_3 according to this equation?

$$4\ PH_3\ (g) + 6\ O_2\ (g) \rightarrow 6\ H_2O\ (\ell) + P_4O_6\ (s)$$

(A) 32.0
(B) 89.6
(C) 134
(D) 146

50. How many moles of FeS_2 are required to produce 64 grams of SO_2 according to the balanced equation below?

$4\ FeS_2\ (s) + 11\ O_2\ (g) \rightarrow 2\ Fe_2O_3\ (s) + 8\ SO_2\ (g)$

(A) 0.40
(B) 0.50
(C) 3.2
(D) 4.5

51. Is the reaction below endothermic or exothermic?

$3\ N_2H_4 \rightarrow 4\ NH_3 + N_2$

H_f: +51 −46 0

(A) Endothermic
(B) Exothermic
(C) Neither endothermic nor exothermic
(D) It cannot be determined

52. What is the value of ΔH_{rxn} for the following reaction?

$CaO(s) + CO_2 \rightarrow CaCO_3(s)$

H_f: −635 −394 −1207

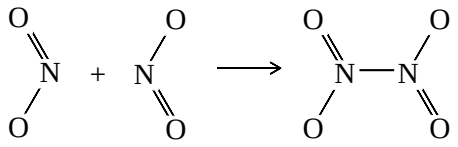
(A) −2236 kJ/mol
(B) −178 kJ/mol
(C) +178 kJ/mol
(D) +2236 kJ/mol

53. Consider the following reaction:

$2\ C{\equiv}O + O{=}O \rightarrow 2\ O{=}C{=}O$

The average bond energies in (kJ/mol) are:
C≡O 1070 C=O 745 O=O 495
What is the value of ΔH_{rxn}?
(A) −1145 kJ/mol
(B) −345 kJ/mol
(C) +345 kJ/mol
(D) +1145 kJ/mol

54. Consider the reaction:

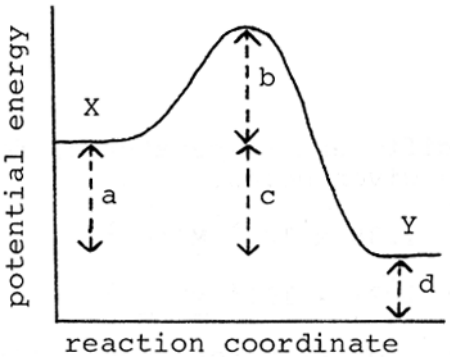


The average N−N bond energy is 160 kJ/mol.
What is the value of ΔH_{rxn}?
(A) −160 kJ/mol
(B) 0 kJ/mol
(C) +160 kJ/mol
(D) +320 kJ/mol

55. Which one of the following changes will result in a decreased rate of reaction?
(A) adding a catalyst
(B) heating up the reactants
(C) cutting the reactants into smaller pieces
(D) diluting the reactants

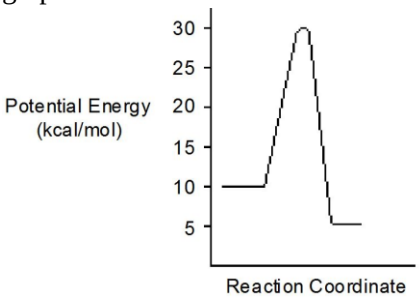
56. Photographic film is sometimes kept in the refrigerator
(A) because cold film results in sharper pictures.
(B) to slow down the chemical reactions on the film.
(C) to protect the film from light.
(D) because the cold insulates the film.

57. What distance corresponds to the activation energy for the reaction of X to Y?



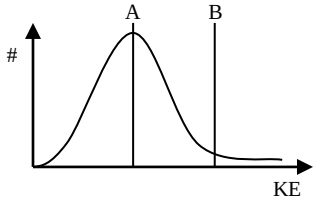
(A) a
(B) b
(C) c
(D) d

58. What is the ΔH_{rxn} for the reaction shown on the graph?



(A) −15 kcal/mol
(B) −5 kcal/mol
(C) +5 kcal/mol
(D) +10 kcal/mol

Questions 59-60: Refer to the following kinetic energy graph. Lines A and B represent the average kinetic energy and the threshold energy, respectively.



59. If the temperature of the system is increased, how will the graph change?
(A) A will increase, while B remains the same.
(B) B will increase, while A remains the same.
(C) Both A and B will increase.
(D) Both A and B will remain the same.

60. If B decreases while A increases, which of the following may have happened?
I. The reaction mixture was heated.
II. A catalyst was added.
III. The surface area of the reaction mixture was increased.
(A) I only.
(B) II and III only.
(C) I and II only.
(D) I, II, and III.

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61. Consider the reaction: $2\ NO(g) + O_2(g) \leftrightarrows 2\ NO_2(g)$
At equilibrium, [NO] = 0.10 M, [O_2] = 0.10 M, and [NO_2] = 0.010 M. This reaction is considered:
(A) Reactant-favored
(B) Product-favored
(C) Neither reactant- nor product-favored
(D) It cannot be determined

62. What is the expression for the equilibrium constant for the following reaction:
$H_2\ (g) + I_2\ (s) \leftrightarrows 2\ HI\ (g)$
(A) $\frac{[H_2][I_2]}{[HI]^2}$
(B) $\frac{[HI]^2}{[H_2][I_2]}$
(C) $\frac{[H_2]}{[HI]^2}$
(D) $\frac{[HI]^2}{[H_2]}$

63. This reaction takes place in solution:
$A \leftrightarrows 2\ B$
At equilibrium, [A] = 0.1 M and [B] = 0.1 M.
What is the value of the equilibrium constant, K_{eq}?
(A) 0.10
(B) 0.20
(C) 1.0
(D) 10

Questions 64-68: The value of K_{eq} for the following reaction is 1.5×10^{-9}.
heat + H_2SO_3 (aq) $\leftrightarrows$ 2 H^+ (aq) + SO_3^{2-} (aq)

64. Which of the following may indicate that equilibrium has been reached?
I. $[H_2SO_3] = [H^+] = [SO_3^{2-}]$
II. Equal moles of H^+ and SO_3^{2-} have been added.
III. The pH remains constant.
(A) II only.
(B) III only.
(C) I and III only.
(D) I, II, and III.

65. Which of the following is the correct expression for the equilibrium constant, K_{eq}, for the reaction?
(A) $\frac{[H_2SO_3]}{[H^+][SO_3^{2-}]}$
(B) $\frac{[H_2SO_3]}{[H^+]^2[SO_3^{2-}]}$
(C) $\frac{[H^+]^2[SO_3^{2-}]}{[H_2SO_3]}$
(D) $\frac{2[H^+][SO_3^{2-}]}{[H_2SO_3]}$

66. In an equilibrium mixture, $[H_2SO_3] = 0.0015\ M$, and $[SO_3^{2-}] = 1.0 \times 10^{-2}\ M$. What is the $[H^+]$ in this mixture?
(A) $1.5 \times 10^{-5}\ M$
(B) $1.0 \times 10^{-4}\ M$
(C) $1.0 \times 10^{-2}\ M$
(D) $2.0 \times 10^{-2}\ M$

67. To a mixture already at equilibrium, which of the following would have a greater concentration if H_2SO_3 (aq) were added?

I. H_2SO_3

II. H^+

III. SO_3^{2-}

(A) I only.

(B) II only.

(C) II and III only.

(D) I, II, and III

68. Which of the following conditions would produce the highest $[H_2SO_3]$?

(A) pH = 2.0 T = 10°C

(B) pH = 2.0 T = 40°C

(C) pH = 9.0 T = 10°C

(D) pH = 9.0 T = 40°C

69. Consider the reaction:

$2\ SO_2(g) + O_2(g) \leftrightarrows 2\ SO_3(g) + \text{heat}$

which of the following would shift the reaction to produce more $SO_2(g)$?

(A) Add O_2 to the reaction mixture.

(B) Increase the volume of the container.

(C) Lowering the temperature.

(D) Remove $SO_3(g)$ to the reaction mixture.

70. In the reaction

$\text{heat} + 2\ HBr(g) \leftrightarrows H_2(g) + Br_2(\ell)$

Under which conditions would produce the most $Br_2(\ell)$?

(A) High temperature, low pressure

(B) High temperature, high pressure

(C) Low temperature, low pressure

(D) Low temperature, high pressure

Answers

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

Part 2: Free Response. For each question, write your response in the space provided. If the problem requires mathematical computation, show your work (steps) neatly, reporting your answer with the correct number of significant digits and units. Partial credit is given only when the process taken is clearly shown. Place a box around or circle your final answer.

- Unit conversions should be shown using dimensional analysis, showing how all units cancel out.
- Work for problems involving formulas should follow the I.E.S.A. form.

1. A particular compound containing only chlorine and oxygen is 52.56% chlorine by mass. The molar mass of the compound is found to be between 60 and 70 g/mol.
   a. Find the empirical formula of the compound. (3 points)

$$\mathbf{n_{Cl} = 52.56\ g\left(\frac{1\ mol\ Cl}{35.45\ g\ Cl}\right) = 1.48\ mol\ Cl}$$

$$\mathbf{n_{O} = 47.44\ g\left(\frac{1\ mol\ O}{16.00\ g\ O}\right) = 2.97\ mol\ O}$$

$$\mathbf{Cl_{\frac{1.48}{1.48}}\ O_{\frac{2.97}{1.48}} \rightarrow ClO_2}$$

   b. Find the molecular formula of the compound. (2 points)

Mass of Empirical Formula: 1(35.45) + 2(16.00) = 67.45 g/mol

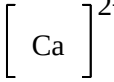
$$\mathbf{\frac{Molar\ Mass}{Empirical\ Formula\ Mass} = \frac{60\text{-}70\ g/mol}{67.45\ g/mol} \approx 1}$$

Molecular Formula = 1(ClO_2) = ClO_2

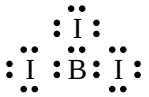
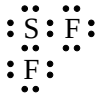
   c. A 1.680 L sample of this compound was obtained at STP. How many molecules are in this sample? (3 points)

$$\mathbf{1.680\ L\left(\frac{1\ mol}{22.4\ L}\right)\left(\frac{6.02 \times 10^{23}\ molecules}{1\ mol}\right) = 4.52 \times 10^{22}\ molecules}$$

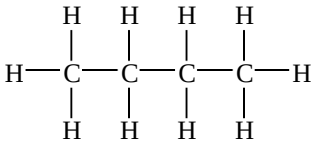
2. Consider the compounds CO and CaO. Draw the Lewis Structures for the following compounds. Then identify the type of solid formed, and the major inter-particle forces involved. (3 points)

Compound:	CO	CaO
Lewis Structures:		
Type of Solid Formed:	**Molecular Solid**	**Ionic Solid**
Inter-Particle Forces	**Dipole-dipole Interactions**	**Ionic Bonds**

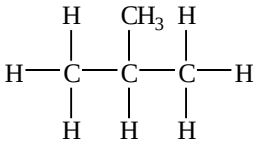
3. Complete the chart for the following compounds: (5 points)

Compound:	BI_3	SF_2
Lewis Structure		
Molecular Shape	**Trigonal Planar**	**Bent**
Bond Angles	**120°**	**104°**
Molecule is	Polar | **Non-Polar**	**Polar** | Non-Polar
Type of IMF:	**London Dispersion Forces**	**Dipole-dipole Interactions**

4. A refrigerant has a molecular formula C_4H_{10}.
   a. Draw two possible structural formulas for C_4H_{10} and name them. (4 points)



Butane

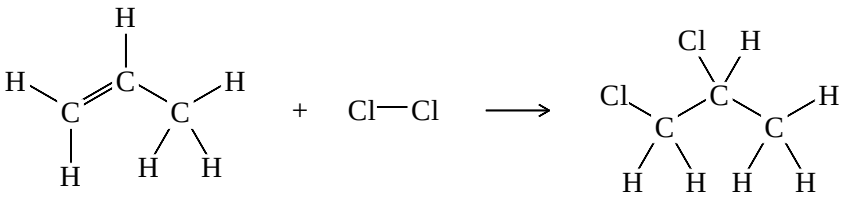


methylpropane

   b. Write the balanced equation for the combustion of C_4H_{10}. (4 points)

$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$

5. Write the equation for the reaction between propene and chlorine gas using structural formulas. (2 points)



6. Complete the table for aqueous samples of each compound, predicting its color in cabbage juice and its conductivity with a light bulb, and writing its dissociation equation. (4 points)

	Compound	Cabbage Juice Color [red | green | purple]	Conductivity [bright | dim | dark]	Dissociation Equation
(i)	HBr	**RED**	**BRIGHT**	**$HBr \rightarrow H^+ + Br^-$**
(ii)	$Mg(OH)_2$	**GREEN**	**DIM**	**$Mg(OH)_2 \leftrightarrows Mg^{2+} + 2\ OH^-$**
(iii)	NH_3	**GREEN**	**DIM**	**$NH_3 + H_2O \leftrightarrows NH_4^+ + OH^-$**

7. Find the pH of a 0.350 M $HC_3H_6O_2$ solution. K_a of $HC_3H_6O_2$ is 1.3×10^{-5}. Show your work using a dissociation equation, K_a expression, and an ICE Table. (4 points)

	$HC_3H_6O_2 \leftrightarrows H^+ + C_3H_6O_2^-$		
Initial	**0.350 M**	**0 M**	**0 M**
Change	**− x**	**+ x**	**+ x**
Equil.	**0.35 – x**	**x**	**x**

$$\mathbf{K_a = \frac{[H^+][C_3H_6O_2^-]}{[HC_3H_6O_2]} = 1.3 \times 10^{-5}}$$

$$\mathbf{\frac{(x)(x)}{(0.35 - x)} = 1.3 \times 10^{-5}}$$

$$\mathbf{x = 2.1 \times 10^{-3} = [H^+]}$$

$$\mathbf{pH = -\log(2.1 \times 10^{-3}) = 2.67}$$

8. Consider the following reactions. Lead metal is placed in a solution of hydrochloric acid. (3 points)

   a. Balanced molecular equation: $\mathbf{Pb\ (s) + 2\ HCl\ (aq) \rightarrow H_2\ (g) + PbCl_2\ (s)}$

   b. Balanced net ionic equation. $\mathbf{Pb\ (s) + 2\ H^+ + 2\ Cl^- \rightarrow H_2\ (g) + PbCl_2\ (s)}$

   c. Which element is oxidized? **Pb** Which element is reduced? **H (or H^+)**

9. Consider the compound isopropyl alcohol, or 2-propanol, C_3H_8O (ℓ).

   a. Write the balanced equation for the combustion of 2-propanol. (1 point)

   $$\mathbf{2\ C_3H_8O\ (\ell) + 9\ O_2\ (g) \rightarrow 6\ CO_2\ (g) + 8\ H_2O\ (\ell)}$$

   b. What volume (in L) of CO_2 at STP can be produced if 4.05 g C_3H_8O is burned? (3 points)

   Molar Mass = 3(12.01) + 8(1.008) + 1(16.00) = 60.094 g/mol

   $$\mathbf{4.05\ g\ C_3H_8O \left(\frac{1\ mol\ C_3H_8O}{60.094\ g\ C_3H_8O}\right)\left(\frac{6\ mol\ CO_2}{2\ mol\ C_3H_8O}\right)\left(\frac{22.4\ L\ CO_2}{1\ mol\ CO_2}\right) = 4.53\ L\ CO_2}$$

   c. If 4.25 L of CO_2 was actually produced in (b) above, what was the percent yield of CO_2? (1 point)

   $$\mathbf{\%\ yield = \frac{actual\ yield}{theoretical\ yield} \times 100\% = \frac{4.25\ L}{4.53\ L} \times 100\% = 93.8\%}$$

   d. What is the ΔH_{rxn} if 1025 kJ of energy is released when 30.5 g C_3H_8O is burned? (2 points)

   $$\mathbf{\Delta H_{rxn} = \frac{q}{n_{rxn}} = \frac{-1025\ kJ}{30.5\ g\ C_3H_8O}\left(\frac{60.094\ g\ C_3H_8O}{1\ mol\ C_3H_8O}\right)\left(\frac{2\ mol\ C_3H_8O}{1\ mol\ reaction}\right) = -4039\ kJ/mol}$$

   e. The enthalpies of formation, ΔH_f, of CO_2 (g) and H_2O (ℓ) are –394 kJ/mol and –286 kJ/mol, respectively. Find the ΔH_f of C_3H_8O. (2 points)

   $$\mathbf{\Delta H_{rxn} = [\Delta H_{f,products}] - [\Delta H_{f,reactants}]}$$

   $$\mathbf{-4039\ kJ/mol = [(6\ mol\ CO_2)(-394\ kJ/mol\ CO_2) + (8\ mol\ H_2O)(-286\ kJ/mol\ H_2O)] - [(2\ mol\ C_3H_8O)(\Delta H_{f,C3H8O}) + (9\ mol\ O_2)(0\ kJ/mol\ O_2)]}$$

   $$\mathbf{\Delta H_{f,C3H8O} = 306.5\ kJ/mol}$$

10. Given the following reaction: $2\ NH_3\ (g) + H_2O_2\ (g) \rightarrow N_2H_4\ (g) + 2\ H_2O\ (\ell)$

The following reaction rate data was obtained:

Trial	$[NH_3]$	$[H_2O_2]$	Initial Rate of Appearance of N_2H_4
1	0.010 M	0.010 M	3.6 M/min
2	0.010 M	0.030 M	10.8 M /min
3	0.020 M	0.010 M	14.4 M /min

a. Write the rate law for this reaction. (3 points)

Rate = $k[NH_3]^x[H_2O_2]^y$

Using experiments 1 and 3,

$$\frac{14.4\ \underline{M}/min}{3.6\ \underline{M}/min} = \frac{k(0.020\ \underline{M})^x(0.010\ \underline{M})^y}{k(0.010\ \underline{M})^x(0.010\ \underline{M})^y} \qquad 4 = (2)^x \qquad x = 2$$

Using experiments 1 and 2,

$$\frac{10.8\ \underline{M}/min}{3.6\ \underline{M}/min} = \frac{k(0.010\ \underline{M})^2(0.030\ \underline{M})^y}{k(0.010\ \underline{M})^2(0.010\ \underline{M})^y} \qquad 3 = (3)^y \qquad y = 1$$

Rate = $k[NH_3]^2[H_2O_2]^1$

b. Find the value of the rate constant, k. Include units. (1 points)

Using Experiment 1

$$k = \frac{rate}{[NH_3]^2[H_2O_2]^1} = \frac{3.6\ \underline{M}/min}{(0.010\ \underline{M})^2(0.010\ \underline{M})^1} = 3.6 \times 10^6\ \underline{M}^{-2}\ min^{-1}$$

11. Consider the reaction: $H_2\ (g) + Cl_2\ (g) \leftrightarrows 2\ HCl\ (g)$. At a particular temperature, $K_{eq} = 841$.

a. Write the equilibrium constant expression for this reaction. (1 point)

$$K_{eq} = \frac{[HCl]_{eq}^2}{[H_2]_{eq}[Cl_2]_{eq}}$$

b. Experiment #1: A reaction mixture is found to contain the following:

$[H_2] = 0.020\ \underline{M}$, $[Cl_2] = 0.020\ \underline{M}$, $[HCl] = 0.38\ \underline{M}$

In which direction will the reaction shift? Justify with calculations. (3 points)

$$Q = \frac{[HCl]^2}{[H_2][Cl_2]} = \frac{(0.38)^2}{(0.020)(0.020)} = 361 < 841$$

Because $Q < K_{eq}$, the reaction will go in the forward direction.

c. What are the concentrations of all substances when the reaction reaches equilibrium? Show work using an ICE Chart. (4 points)

	$H_2\ (g)$	+ $Cl_2\ (g)$	$\leftrightarrows 2\ HCl\ (g)$
I	0.020	0.020	0.38
C	– x	– x	+ 2x
E	0.02-x	0.02-x	0.38+2x

$$K_{eq} = \frac{[HCl]_{eq}^2}{[H_2]_{eq}[Cl_2]_{eq}} = \frac{(0.38 + 2x)^2}{(0.020 - x)(0.020 - x)} = 841 \qquad x = 0.00645\ \underline{M}$$

$[H_2]_{eq} = [Cl_2]_{eq} = 0.014\ \underline{M}$; $[HCl]_{eq} = 0.393\ \underline{M}$