Experiment 1

Acid and Base Classifications

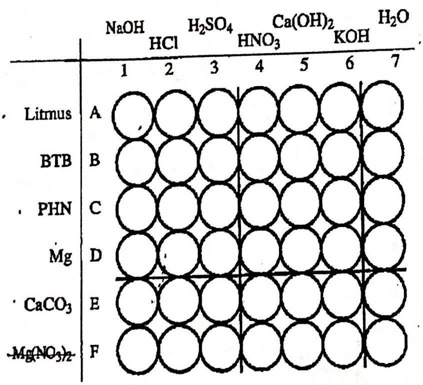
Acids and bases are classes of chemical compounds. There are weak and strong acids and bases based on their ability to dissociate in aqueous solution. They can interact with each other. Be careful when you handle acid or base in any situation. Please read the lab safety section carefully and consult with your instructor if necessary.

Problem Statement: *What are the characteristics of acid and base solutions?*

Part I

Data Collection: *Properties of acids and bases*

A. Set up a 96 well micro-plate on the lab bench. Label rows and columns which can be seen in figure below. With a medicinal dropper or dropper bottle carefully ½ fill each well of column 1(***rows A-F***) with 1.00 M NaOH solution.



B. Do the same with columns 2-7 with 1.00 M HCl, 1.00 M H_2SO_4, 1.00 M HNO_3, saturated $Ca(OH)_2$, 1M KOH and distilled water respectively. Rinse the dropper when changing solutions.

C. Dip small pieces of red and blue litmus paper in each of the solutions in row **A** (see diagram) and record your observations in the table on the next below.

D. Add one microdrop bromothymol blue (BTB) to each of the solutions in row **B** and one microdrop of phenolphthalein (PHN) to each of the solutions in row **C.** Record your observation in the table.

E. Place a small piece of magnesium (Mg) metal in each of the solutions in row **D.** Record your observation in the table.

F. Place a small amount of $CaCO_3$ in each of the solutions in row **E.** Record your observation in the table.

G. Add one microdrop of $Mg(NO_3)_2$ solution to each of the solutions in row **F.** Record your observation in the table.

Record your observations

	NaOH	HCl	H_2SO_4	HNO_3	$Ca(OH)_2$	KOH	Distilled Water
~~Litmus~~ Blue	Blue	Red	Red	Red	Blue	Blue	Blue
~~Litmus~~ Red	Blue	~~Red~~ Red	~~Red~~ Red	~~Red~~ Red	Blue	Blue	Red
Bromothymol blue	Blue	Yellow	Yellow	Yellow	blue	blue	No change
Phenolphthalein	Purple	No change	No change	No change	Pink	Pink	No change
Mg	No	Babble	Bubble	No	Bubble	No	No
$CaCO_3$	cloudy	cloudy	bubble	Bubble	cloudy	PPT	~~PPT~~ cloudy
~~$Mg(NO_3)_2$~~							

Data Analysis

a. Group the seven solutions according to similar properties. What are the least number of groups needed? What substances are in each group?

Turning Blue litmus to red : Hcl, H_2SO_4, HNO_3

Turning Red Litmus to Blue : NaOH, $Ca(OH)_2$, KOH

No color change : Distilled water.

Turning Bromothymal blue into blue : NaOH, $Ca(OH)_2$, KOH

Turning Bromothymal blue into yellow : Hcl, H_2SO_4, HNO_3.

No color change of Bromothymal blue : Distilled water.

Turning to Phenolphthalein pin.k : $Ca(OH)_2$, KOH.

Turning Phenolphthalein to purple : NaOH

No color change of ~~Turning~~ Phenolphthalein : Hcl, H_2SO_4, HNO_3, Distilled water

Bubble (Mg) : Hcl, H_2SO_4, $Ca(OH)_2$.

No Bubble (Mg) : NaOH, KOH, Distilled water.

Cloudy ($CaCO_3$) : NaOH, Hcl, $Ca(OH)_2$, Distilled water.

PPT ($CaCO_3$) : KOH.

Bubble ($CaCO_3$) : H_2SO_4, HNO_3.

After ~~gr~~ allocating the all the seven solutions in different group according to similar properties we can see that we are required total 14 different group. But Atleast we can form 3 groups. Those are Acid, Base, Neutral.

① Acid : Hcl, H_2SO_4, HNO_3

② Base : NaOH, $Ca(OH)_2$, KOH

③ Neutral : Distilled water.

b. Write an equation for any one of the reaction you observed when you added the ~~$Mg(NO_3)_2$~~ $CaCO_3$ solutions?

$$CaCO_3 + H_2SO_4 (aq) \longrightarrow CaSO_4 + H_2O + CO_2$$

Part II

Data Collection: ***Reactions of acids and bases***

Obtain 20.00 mL of 1.00 M HCl and divide it equally into two 50.00 mL beakers. Mark them as beaker 1 and beaker 2.

Beaker 1

Put several pieces of Mg metal into beaker 1 and cover it with a watch glass. Wait few minutes, don't remove the watch glass. Hold a lighted match to the pouring spout of the beaker. Write down your observations. Write a chemical equation which represents the reaction.

When the inflamed match stick put around the lid of beaker, it made an explosion with pop sound and goes off.

Chemical equation:

$$2HCl + Mg \longrightarrow MgCl_2 + H_2$$

Beaker 2

Put several chips of $CaCO_3$ into the second beaker of 1.00 M HCl solution and test with a lighted match. Record your observation and Write a chemical equation which represents the reaction.

When the inflamed match stick put inside the beaker, it goes off silently.

Chemical equation:

$$2HCl + CaCO_3 \longrightarrow CaCl_2 + CO_2 + H_2O$$

Data Interpretation for part I and part II

a. **Suppose HCl is one of a class of compounds call "acid" and NaOH is one of class of compounds called "base". What did you learn about them in this experiment so far?**

From the experiment, I saw that HCl and other acids turned blue litmus paper into red. and no color change for red litmus paper. When we gave Bromothymol blue ~~into~~ the HCl solution, ~~its~~, the solution turned ~~it~~ into yellow. When we added Mg, the HCl solution created some bubbles and when we added $CaCO_3$ the solution turned cloudy. ~~The~~ On the other hand, NaOH is a base that turned Red litmus paper into blue because of OH^- ion. and no color change for Blue litmus paper. When we added Bromothymol blue, the NaOH solution turned Blue. It also turned into purple when phenolphthalein was added. It didn't create any bubble when we added the Mg and ~~turn~~ the solution turned cloudy when was

Scanned with CamScanner

HCl cretes Hydrogen gas (H_2) when react with Mg which causes the explosion when came near fire. And when NaOH and HCl react H_2O formed

b. From there chemical formula given, identify the similarities and differences among each of the groups you identified in the data analysis section of **Part I.**

From the groups of Part I, we can see that the group of Acid turned red litmus paper into blue and the group of base turned blue litmus paper into red. But there is no color change for the group of neutrals. The acid group turned the solution after adding Bromothymal into yellow, on the other hand the base group turned the solution into blue after adding the Bromothymal. But the neutral group showed no color change. When we added the phenolpthalein in the solution of base group either the solution turned pink or purple. The acid group and neutral group compounds solution didn't show any color change when phenolpthalein was introduced.

Part III

Data Collection: Concentrations of acids and bases

a. Obtain 10.00 mL of a 0.10 M HCl solution in a clean test tube and label it "10^{-1} M H^{+}". Transfer 1.00 mL of 10^{-1} M HCl solution to a test tube and add 9.00 mL of distilled water in it. Mix it thoroughly and label the test tube as "10^{-2} M H^{+}". Rinse and shake dry the transferring glass wires. Repeat the procedure to prepare solutions 10^{-3} M H^{+}", 10^{-4} M H^{+}" and "10^{-5} M H^{+}".

b. Again obtain 10.00 mL of 0.10 M NaOH in a test tube and label it as "10^{-1} M OH^{-}". Repeat above serial dilution procedure to prepare up to "10^{-5} M OH^{-}" solution.

c. Obtain a centimeter long strip of a broad range pH paper. Dip a glass rod into distilled water and touch that to a small section of a pH paper. Compare the color of the paper with the color code provided with the paper and record the value in the table below. Using the same procedure, test the 10 solutions you made in sections a and b above.

Distilled water pH = 7

Acid		Base	
Dilution	pH	Dilution	pH
10^{-1}	1	10^{-1}	13.5
10^{-2}	2.5	10^{-2}	12.5
10^{-3}	5	10^{-3}	11
10^{-4}	6	10^{-4}	9
10^{-5}	7	10^{-5}	8

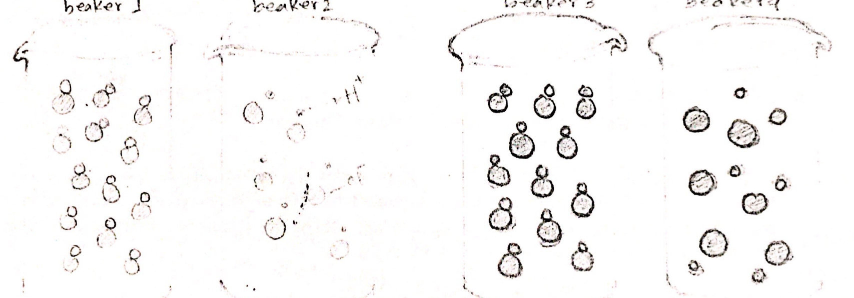
Data Analysis and Interpretation

a. What conclusions can be drawn from these data?

From the data of the table, we can see that ~~from~~ for an concentrated acid, HCl the ph is lowest and concentrated base, NaOH the ph is Highest, 13.5. The more we ~~dia~~ dilute the acid using distilled water which has ph of 7, the more ph is increasing and trying to reach neutral ph of 7. On the other hand more we are dialuting the NaOH using water we can see the decrease of ph ~~and~~. We can conclude that as the H^+ is decreasing of dilute acid the ph is going up to the neutral position and the OH^- is decreasing of of dilute base the ph is going down to to the neutral ph.

b. **Mental Model:** Draw a series of pictures that contrasts four of your dilutions (two acids and two bases) with each other and represents the atomic and molecular species involved. Explain how your picture illustrates your observations.

beaker 1 | beaker 2 | beaker 3 | beaker 4



concentrated HCl | diluted HCl | Concentrated NaOH | diluted NaOH

○ → H^+
○ → Cl^-

o → OH^-
● → Na^+

In the above picture, the beaker 1 consist of concentrated 1 mL 10^{-1} M HCl solution. After Adding 9 ml more distilled wated the HCl become diluted and from the picture we can see less H^+ in beaker 2 than beaker 1. less H^+ means more ph. On the beaker 3 we take concentrated NaOH which has a ph of 13.5. ~~Here~~ ~~the OH^-~~ After adding water the NaOH become diluted and the number of ~~ion~~ OH^- ion decrease which we can see in the beaker 4.

REPORT SUBMISSION DATE ....15/03/22........

EXPERIMENT 2

DISSOLUTION REACTIONS: HEATS OF DISSOCIATION

Heats (exothermic or endothermic) are associated with chemical reactions. Quantity of heat evolved or absorbed is directly proportional to the amount reacted. Consider the reaction:

$$MgSO4(s) + H_2O\ (l) \longrightarrow Mg^{2+}(aq.) + SO_4^{2-}(aq.) \pm \text{heat}$$

Heat could be generated or absorbed in this reaction. When heat is generated/released from a chemical reaction it is called exothermic reaction (you can feel it by touching the reaction container (warmer) and when heat is absorbed the reaction is called endothermic (colder). When reactions occur in a reaction vessel (*e.g.,* Beaker) in aqueous condition, formation and dissociation of chemical bonds occur simultaneously. Bond formation and dissociation involves heat energy of the system which is expressed by the term Q which is called enthalpy.

PROBLEM STATEMENT: *Is heat energy related to chemical reactions, how?*

This experiment is subdivided into two parts:

I. QUALITATIVE & II. QUANTITATIVE

PART I. QUALITATIVE

DATA COLLECTION:
Place about 30 mL of distilled water into a 50 mL beaker. Suspend a thermometer (having 0.1°C division mark) into the beaker using thermometer clamp and ring stand. Please make sure that the thermometer is not touching the bottom of the beaker, as any movement of the beaker could break the thermometer. Record the temperature of water in the beaker in every 30 seconds for 240 seconds.

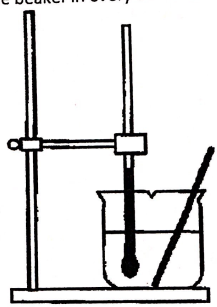


FIGURE 1: Experimental setup for dissolution reaction

Place a moderate amount (which would be 1 to 3 cm³) of supplied anhydrous magnesium sulfate ($MgSO_4$) to the beaker. Mix vigorously with the glass rod for 5 minutes. Record your observations. **(2 points)**

$MgSO_4$ – 23.75°c – 30.25°c – Exothermic

$MgSO_4$-

Repeat this procedure with each of the following compounds: **(2 points)**

a. Sodium Nitrate, $NaNO_3$

$NaNO_3$ – 23.5°c – 22°c → Endothermic

b. Sodium Chloride, NaCl

NaCl – 24°c – 23°c — Endothermic

c. Hydrated Calcium Chloride, $CaCl_2.2H_2O$

$CaCl_2 \cdot 2H_2O$ — 23°c – 25°c → Exothermic

d. Ammonium Nitrate, NH_4NO_3

NH_4NO_3 → 23°c → 21.75°c → Endothermic

DATA ANALYSIS:

What are the similarities and differences in the behavior of these compounds? Can you find out any generalization concerning all chemical reactions here? What conclusion can be drawn from these data?

(4 points)

Among the total 5 compounds, three of them ~~is~~, $NaNO_3$, $NaCl$ and NH_4NO_3 showed endothermic reaction while they are supplied in the distilled water and other two compounds, $MgSO_4$ and $CaCl_2 \cdot 2H_2O$ showed exothermic reaction. Here $NaNO_3$, $NaCl$ and NH_4NO_3 required heat to break the bond and disolved in water and they get this required energy from the water thats why we saw a decrease in temperature of ~~water~~, the solution. On the other hand $MgSO_4$ and $CaCl_2 \cdot 2H_2O$ produced energy while disolving in the water and relise the heat in the solution, as a result the temperature of the solution rises. So, we can conclude that the compounds that reqaired energy from outside for dissolution are endothermic and the compounds that produce heat/energy during dissolution are exothermic.

PART II. QUANTITATIVE

DATA COLLECTION:

a. Accurately weigh a 3 to 5 gm sample of $MgSO_4$ on the analytical balance. Record the exact mass here. For 4 different trials below measure four different weight samples (e.g., 1,2, 4 & 5 grams respectively).
b. Suspend the thermometer into a polystyrene cup/coffee cup. Make sure of the thermometer is not touching the bottom of the cup. Measure 20 mL of distilled water by a volumetric cylinder into the cup and stir for 240 second. Record the temperature in every 20 seconds. After 240 seconds add $MgSO_4$ with vigorous mixing while continuing to record data for 5 minutes.
c. Determine the temperature change, ΔT, for the reaction. This can be done from the difference of the highest temperature minus the slope of the line go through the points from first 240 seconds of data.
d. Draw a temperature vs. time graph. Draw the best curve through the points and point out what is happing in each part of the curve.

DATA TABLE:

TRAILS

(I) Mass of $MgSO_4$ 0.5 gm	
Time (s)	Temp(°C)
20	26.0
40	27.3
60	28.0
80	30.0
100	30.1
120	30.5
140	30.5
160	30.5
180	30.5
200	29.8
220	29.5
240	29.1
260	29.2
280	28.8
300	28.1

(II) Mass of $MgSO_4$ 1.0 gm	
Time(s)	Temp(°C)
20	27.1
40	28.0
60	28.3
80	29.3
100	30.5
120	31.5
140	31.5
160	31.5
180	32.0
200	31.8
220	31.5
240	31.0
260	31.0
280	30.8
300	30.8

(III) Mass of $MgSO_4$ 1.5 gm	
Time (s)	Temp(°C)
20	23
40	23
60	23
80	28.5
100	29.5
120	29.5
140	29.5
160	29.5
180	29.75
200	30.0
220	30.0
240	30.0
260	30.1
280	30.1
300	30.1

(IV) Mass of $MgSO_4$ 2.0 gm	
Time(s)	Temp(°C)
20	27.5
40	28.5
60	29.5
80	30.5
100	31.5
120	32.5
140	32.5
160	32.5
180	32.3
200	31.5
220	31.5
240	31.0
260	31.0
280	30.8
300	30.8

DATA ANALYSIS

1. What do you understand form the data you recorded and from the other trials? **(4 points)**

In this experiment we ran 4 trials with different gm (Gram) value of $MgSO_4$. In the all 4 experiments we can see that after introducing the $MgSO_4$ salt in the water, the temperature started to increase and after reaching a certain temperature it started to decrease. While we introduce the $MgSO_4$ salt it started to disolve in water by transforming in Mg^{2+} and SO_4^{2-} and this produce some energy which is later relised in the water, that's why this is a exothermic reaction. We also, saw that after certain level the temperature is decreasing. that means the salt is disolved in the water and no more reaction is happening. The energy $MgSO_4$ produced while disolving in water equal the increased temperature of water.

2. Calculate the heat, Q & moles, n, of the reaction. Take help from the equitation Q = C x M x ΔT. Assume C = 4.18 Joules/gram °C and M is the mass of water (take the water density as 1.00 grams/cm³). **(4 points)**

We know,

Heat (Q) = C * M * ΔT

C = 4.18
M = 20
ΔT = Highest temperature − Initial temperature.

For, Trial 1,

$Q_1 = 4.18 * 20 * (30.5 - 27.1)$

$= 284.24$

$n_1 = \frac{.5 \text{ gm}}{120} = 4.167 \times 10^{-3}$ mole

For, Trial 2,

$Q_2 = 4.18 * 20 * (32 - 27.8)$

$= 351.12$

$n_2 = \frac{1.0 \text{ gm}}{120}$

$= 8.333 \times 10^{-3}$ mole

For, Trial 3,

$Q_3 = 4.18 * 20 * (30.1 - 23)$

$= 4.18 * 20 * 7.1$

$= 593.56$

$n_3 = \frac{1.5 \text{ gm}}{120}$

$= 0.0125$ mole.

For, Trial 4,

$Q_4 = 4.18 * 20 * (32.5 - 28.5)$

$= 334.4$

$n_4 = \frac{2.0 \text{ gm}}{120}$

$= \cancel{0.16}\ 0.0167$ mole.

3. Plot the collected data as moles, n vs. Q. Number of moles can be calculated as n = (mass of sample in gram) / (molecular weight in grams/mole). Try to find an algebraic equation. **(4 points)**

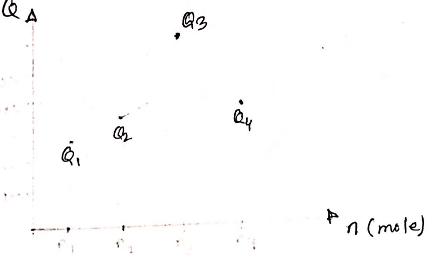
from 2,

$Q_1 = 284.24$; $n_1 = 4.167 * 10^{-3}$

$Q_2 = 351.12$; $n_2 = 8.33 * 10^{-3}$

$Q_3 = 593.56$; $n_3 = 0.0125$

$Q_4 = 334.4$; $n_4 = 0.0167$

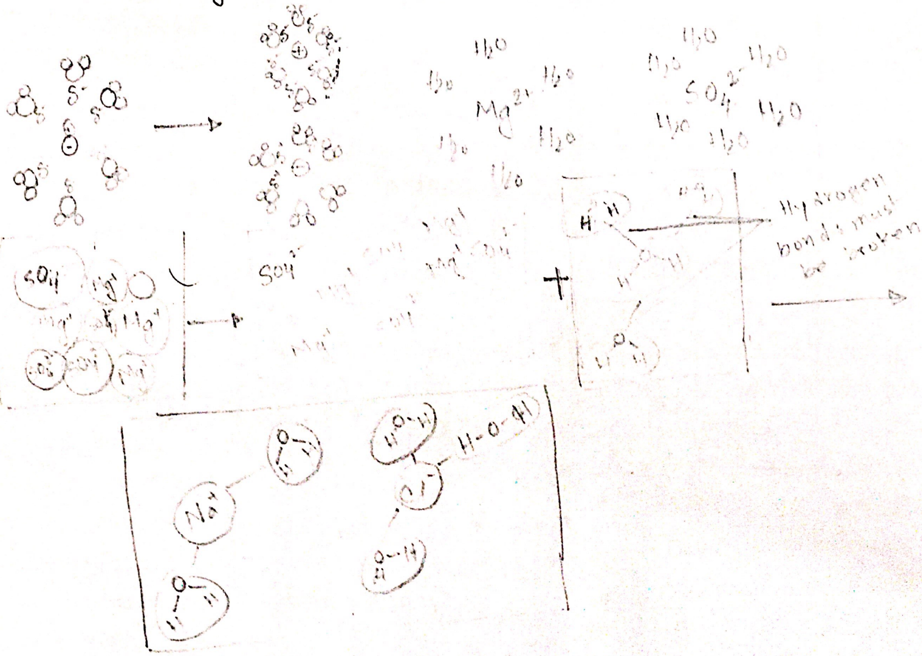


If we treat Q_3 and Q_4 as outlier the line will be a straight ~~fit~~ line that go through Q_1 and Q_2. As we graphically see the ~~that~~ that the line is not going through the origin the algebraic equation will be $Q = mx + c$

FIGURE: plot here

MENTAL MODEL: Use the chemical equation given above to represent the dissolution reaction in this experiment. Draw a picture(s) which describes what is happening in atomic or in molecular level. How heat release or absorbed can be described from these pictures? **(5 points)**

$MgSO_4 + H_2O \longrightarrow Mg^{2+} + SO_4^{2-} + 2H^+ + OH^-$



List #1

1. $SiCl_4$ (no Cl-Cl bonds)
2. PCl_3 (no Cl-Cl bonds)
3. NO_3^- (no O-O bonds)
4. SF_6 (no F-F bonds)
5. PCl_5 (no Cl-Cl bonds)
6. IF_3 (no F-F bonds)
7. XeF_5^+ (no F-F bonds)
8. SO_4^{2-} (no O-O bonds)
9. C_4H_8O
10. C_5H_{12}

List #2

1. CH_3Br (C is central atom)
2. ICl_2^+ (no Cl-Cl bonds)
3. NO_2^- (no O-O bonds)
4. BF_3 (no F-F bonds)
5. HOOH (bonding as in formula)
6. $SbCl_5$ (no Cl-Cl bonds)
7. BrF_3 (no F-F bonds)
8. ICl_4^- (no Cl-Cl bonds)
9. $CH_3CH_2CO_2^-$ (bonding as in formula)
10. C_5H_{10}

List #3

1. PO_4^{3-} (no O-O bonds)
2. H_2NNH_2 (bonding as in formula)
3. CS_2 (no S-S bonds)
4. BCl_3 (no Cl-Cl bonds)
5. SbF_5 (no F-F bonds)
6. PCl_6^- (no Cl-Cl bonds)
7. ClF_5 (no F-F bonds)
8. XeF_2 (no F-F bonds)
9. C_3H_5Cl (C's are central atoms)
10. C_6H_{12} (6 C's in a ring)

List #4

1. NH_4^+
2. SF_2 (no F-F bonds)
3. COF_2 (C is central atom)
4. SO_2 (no O-O bonds)
5. PBr_5 (no Br-Br bonds)
6. $TeCl_4$ (no Cl-Cl bonds)
7. XeF_4 (no F-F bonds)
8. ClO_4^- (no O-O bonds)
9. C_3H_8O
10. C_6H_6 (6 C's in a ring)

MOLECULAR STRUCTURES

Name Tahmid Bin Alam Section 1.

Molecule List #

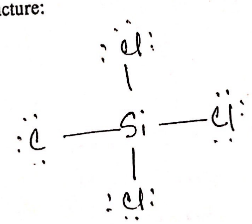
Partner

1. $SiCl_4$

\# valence electrons = $4+(7*4) = 32$

Molecular geometry = Tetrahedral

Lewis Structure:



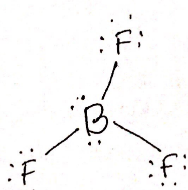
3-D Drawing:

2. BrF_3

\# valence electrons = $7+(7*3) = 28$

Molecular geometry = T-shaped

Lewis Structure:



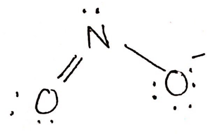
3-D Drawing:

3. NO_2^-

Lewis Structure:

\# valence electrons = $5+(6*2)+1=18$

Molecular geometry = Bent



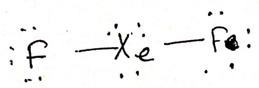
3-D Drawing:

4. XeF_2

Lewis Structure:

\# valence electrons = $8+(7*2)=22$

Molecular geometry = Linear



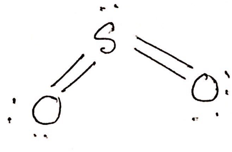
3-D Drawing:

5. SO_2

\# valence electrons = $6+(6*2)=18$

Molecular geometry = Bent

Lewis Structure:



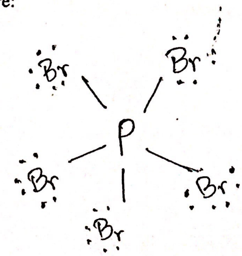
3-D Drawing:

6. PBr_5

\# valence electrons = $5+(7*5)=40$

Molecular geometry = Trigonal bipyramidal

Lewis Structure:



3-D Drawing: