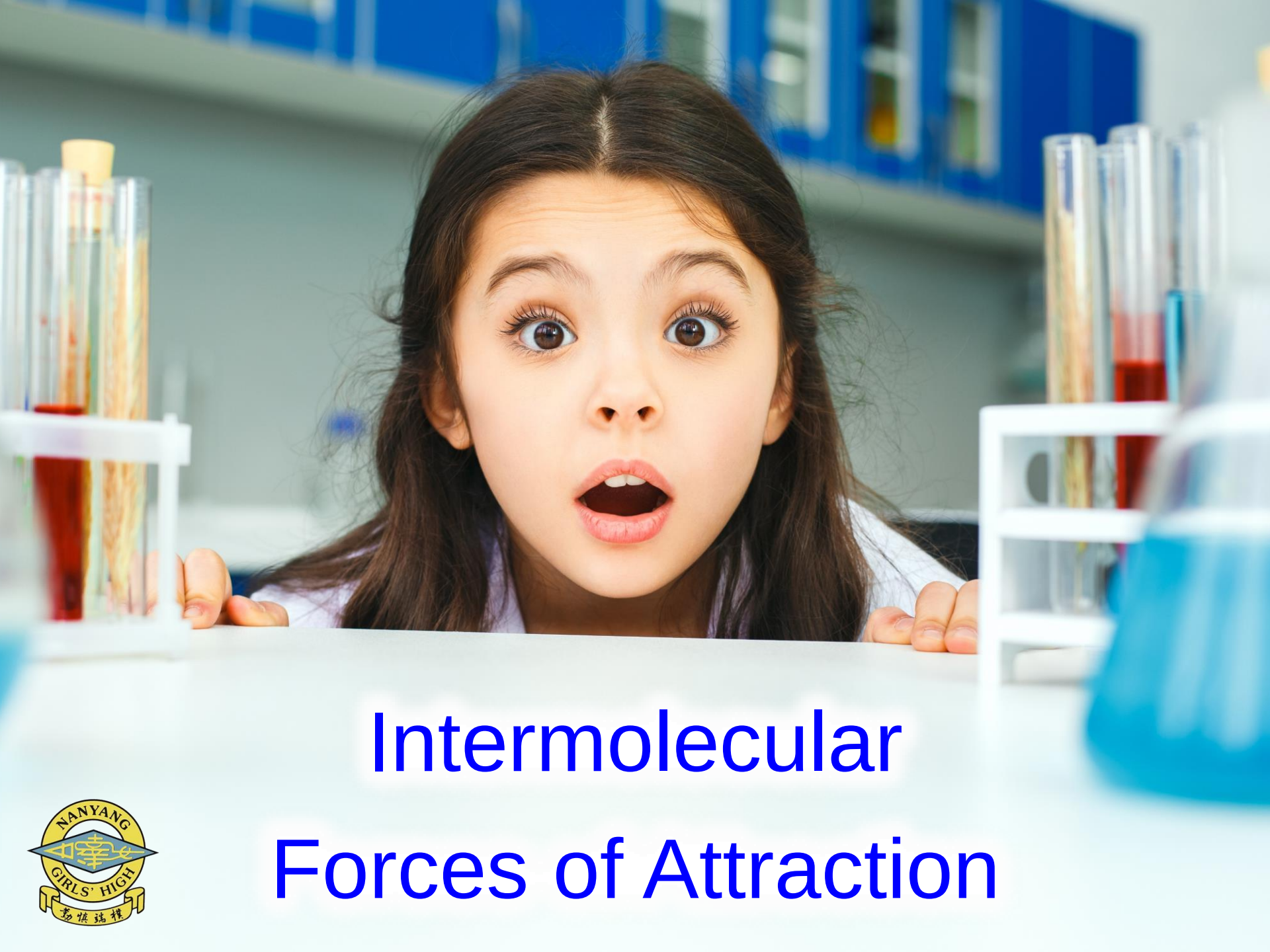
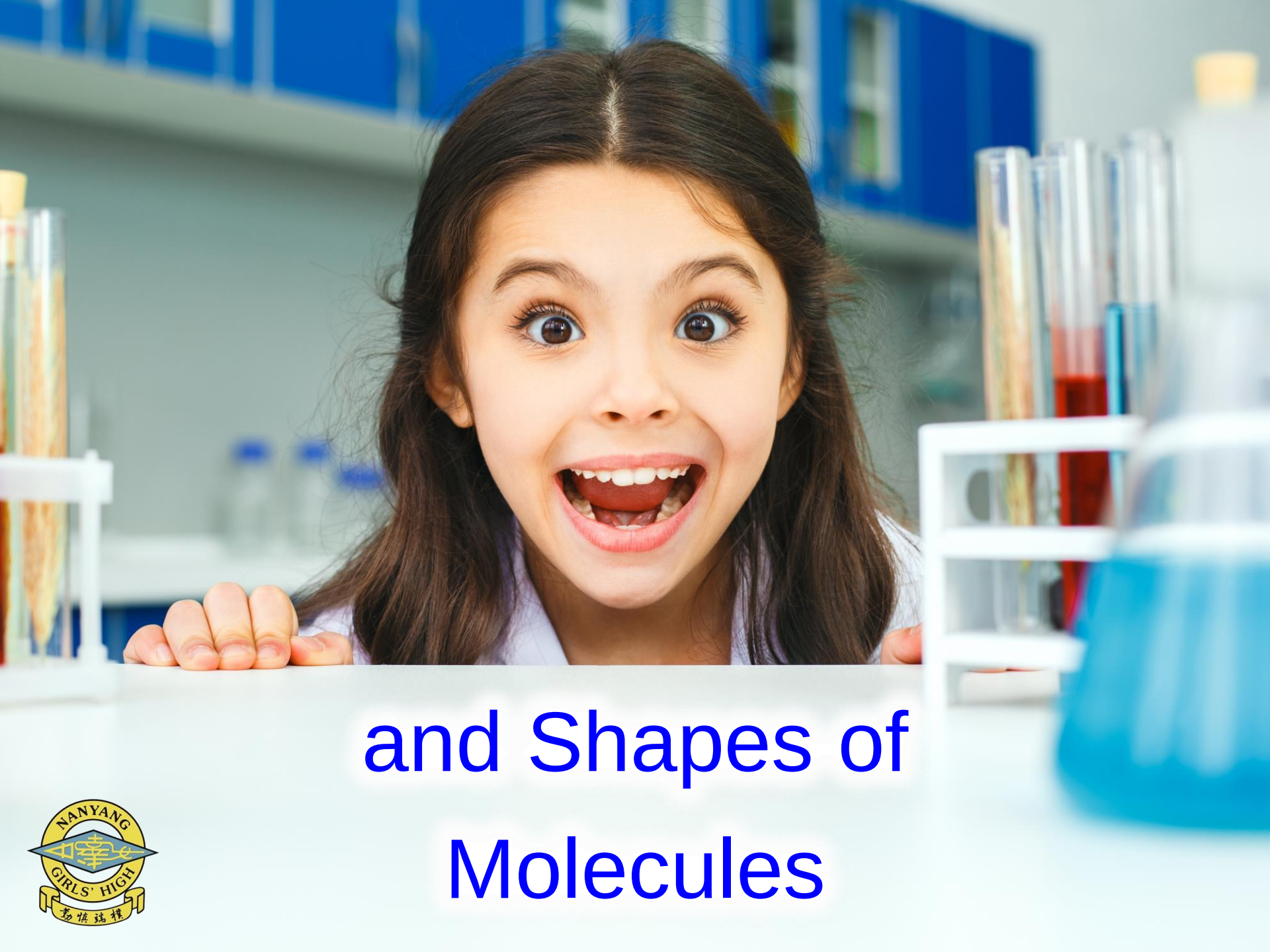


Intermolecular Forces of Attraction



and Shapes of Molecules

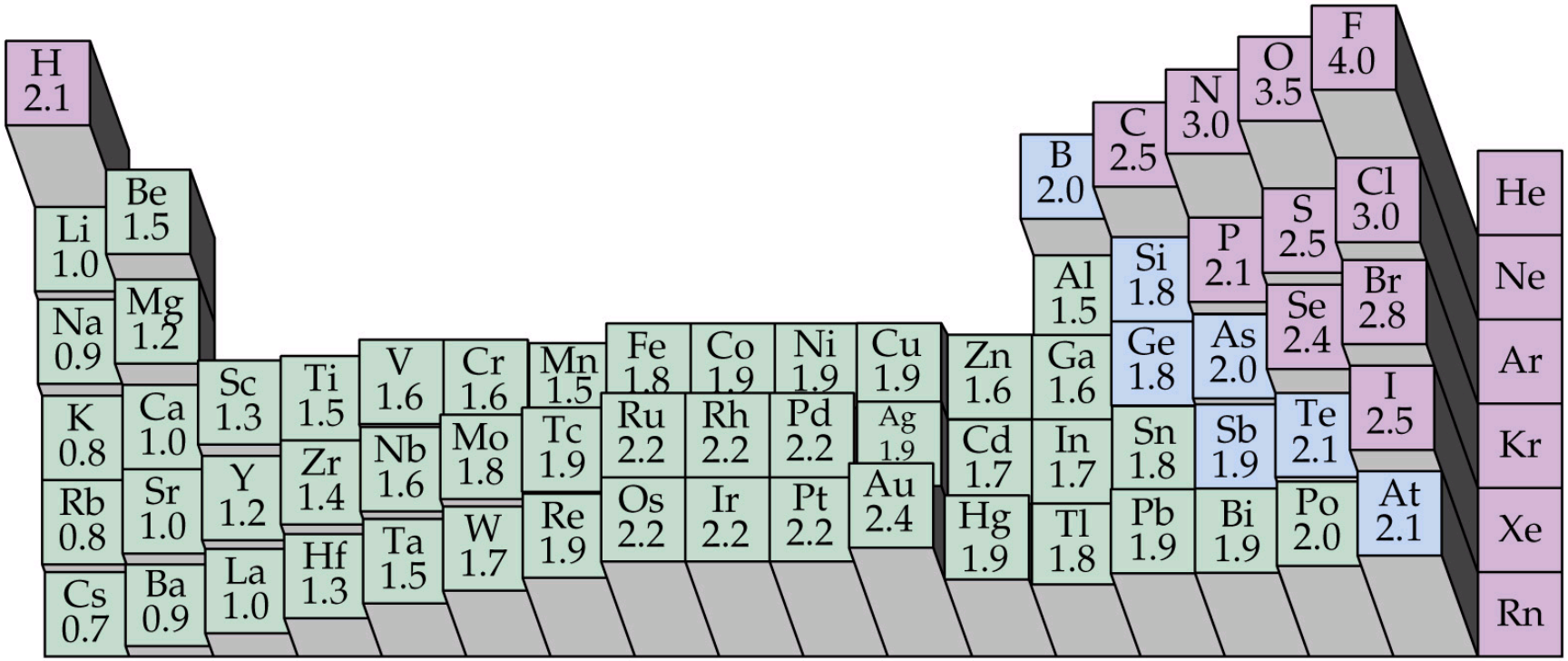
Intermolecular Forces of Attraction and Shapes of Molecules

Relative Strengths of Intermolecular Forces of Attraction						
Stronger	Hydrogen Bonds	**>**	Permanent Dipole – Permanent Dipole	**>**	London Dispersion Forces	**Weaker**

- Hydrogen Bonds: Exist between molecules that contain $\delta+$ H–F $\delta-$ or $\delta+$ H–O $\delta-$ or $\delta+$ H–N $\delta-$ bonds.
- Permanent Dipole – Permanent Dipole Interactions: Exist between molecules in which the atoms directly bonded together differ in their electronegativity values by *0.5 or more*, *e.g.* $\delta+$ H–C*l* $\delta-$.
- Instantaneous Dipole-Induced Dipole (London Dispersion Forces): Exist between molecules in which the atoms directly bonded together differ in their electronegativity values by *0.4 or less*, *e.g.* Cl_2, O_2 and most *hydrocarbons* (*e.g.* CH_4 and C_2H_6).

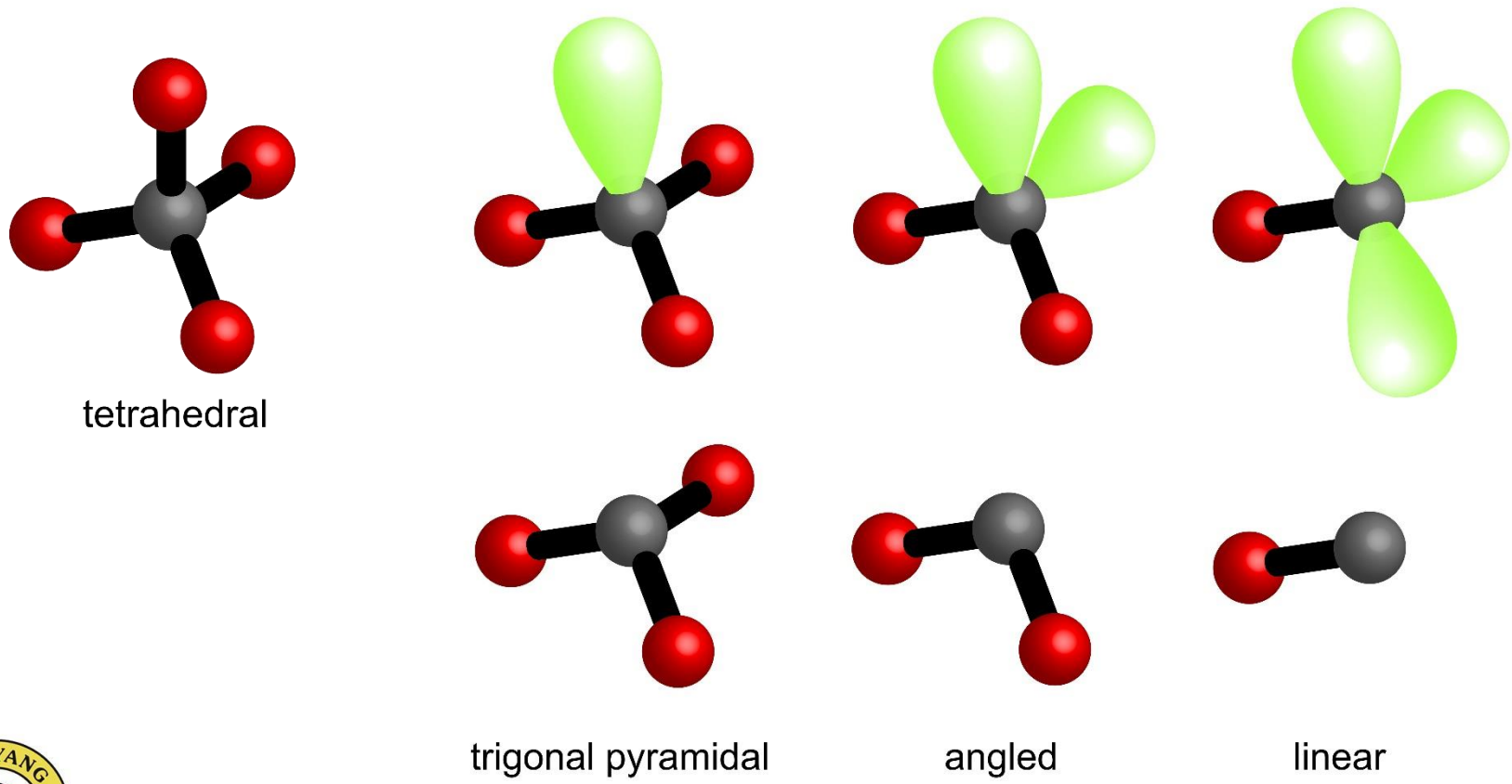
Intermolecular Forces of Attraction and Shapes of Molecules

Electronegativity Values of the Chemical Elements



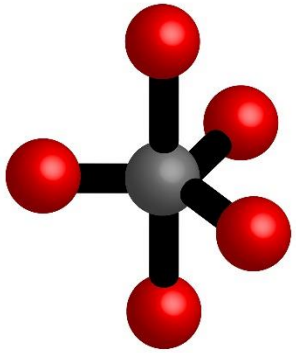
Intermolecular Forces of Attraction and Shapes of Molecules

Summary of Common Shapes

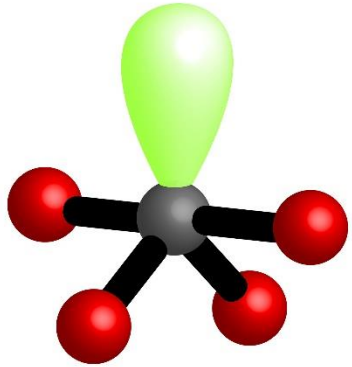


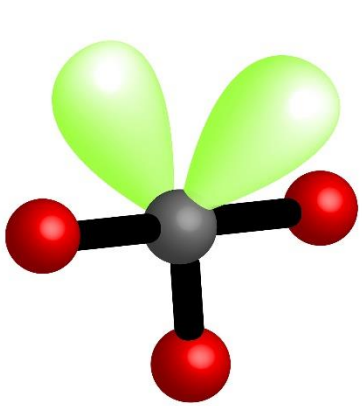
Intermolecular Forces of Attraction and Shapes of Molecules

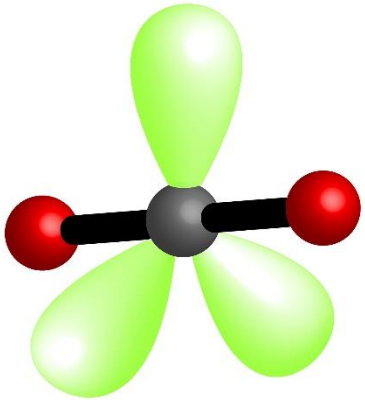
Summary of Common Shapes

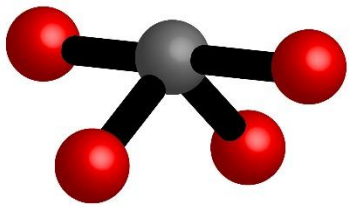


trigonal bipyramidal

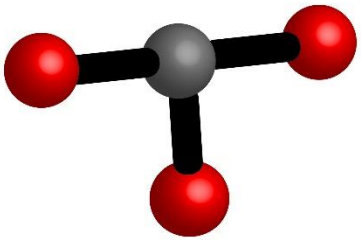




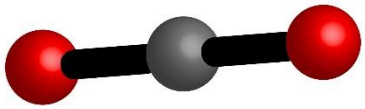




bisphenoidal



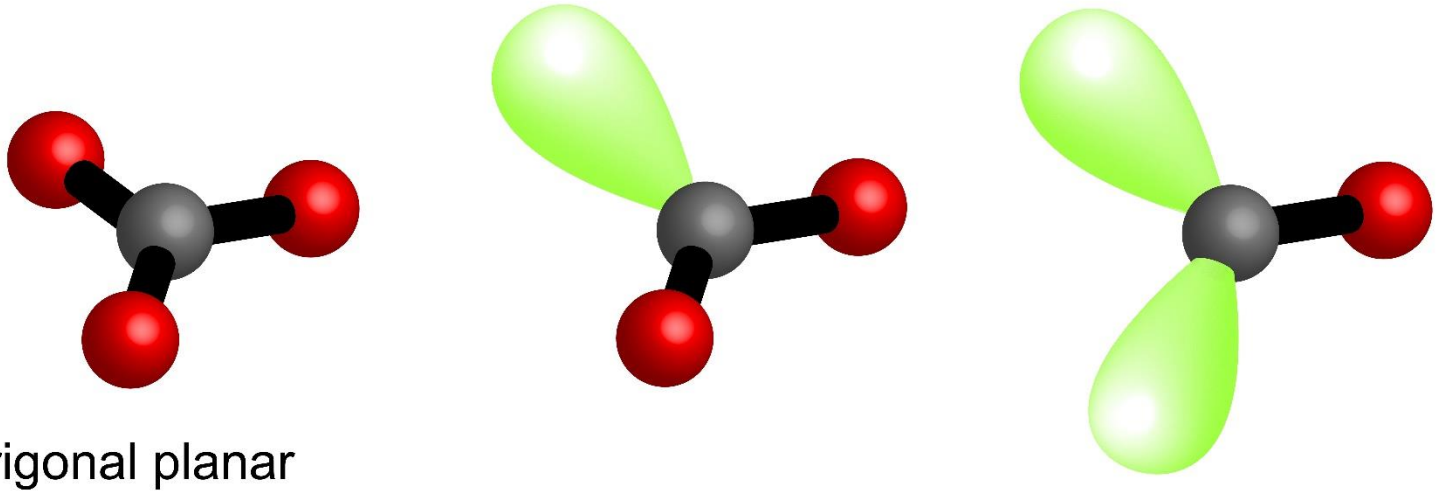
T-shaped



linear

Intermolecular Forces of Attraction and Shapes of Molecules

Summary of Common Shapes



trigonal planar

angled

linear

Intermolecular Forces of Attraction and Shapes of Molecules

- For each one of the following simple covalent molecules state:

1. The number of sigma bonds (σ bonds).

2. The number of pi bonds (π bonds).

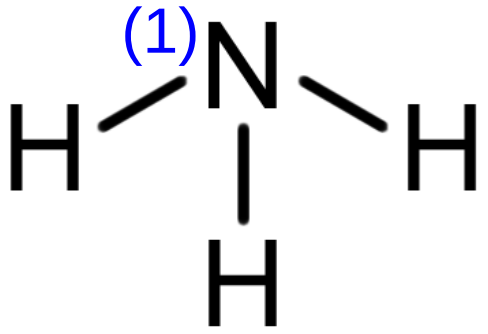
3. The number of lone (non-bonding) pairs of electrons.

4. The shape (geometry) of the molecule, or shape around specific atoms, *e.g.* carbon (1), oxygen (2).

5. The strongest, most significant, intermolecular force of attraction.

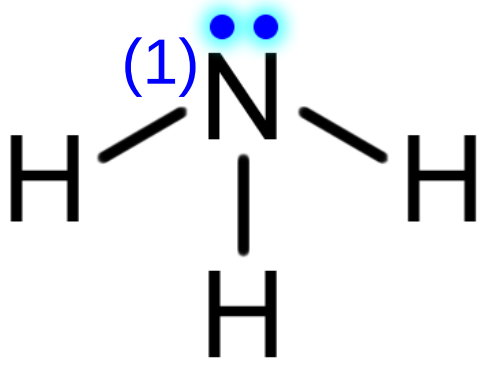
Intermolecular Forces of Attraction and Shapes of Molecules

1. Ammonia



Intermolecular Forces of Attraction and Shapes of Molecules

1. Ammonia

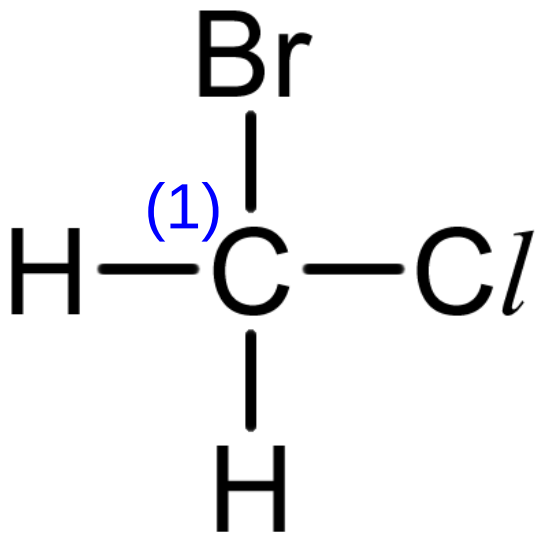


- Lewis Dot Diagram

- Number of sigma bonds = 3
- Number of pi bonds = 0
- Number of lone pair electrons = 1
- Shape around nitrogen (1) = Trigonal pyramidal
- Intermolecular force of attraction = Hydrogen bonding

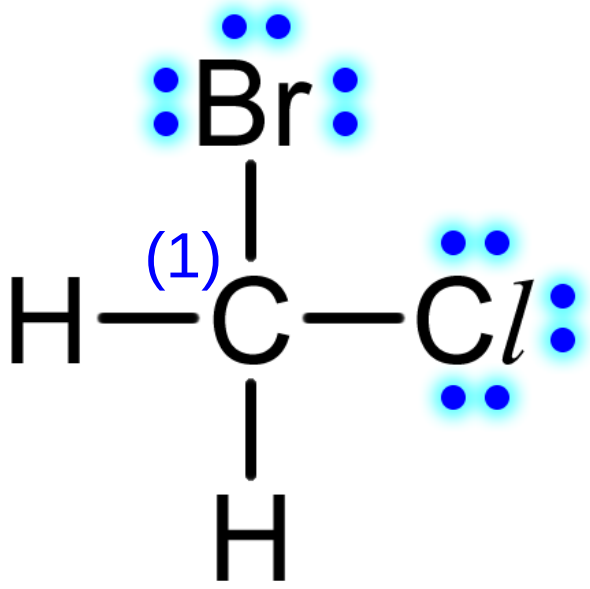
Intermolecular Forces of Attraction and Shapes of Molecules

2. Bromochloromethane



Intermolecular Forces of Attraction and Shapes of Molecules

2. Bromochloromethane

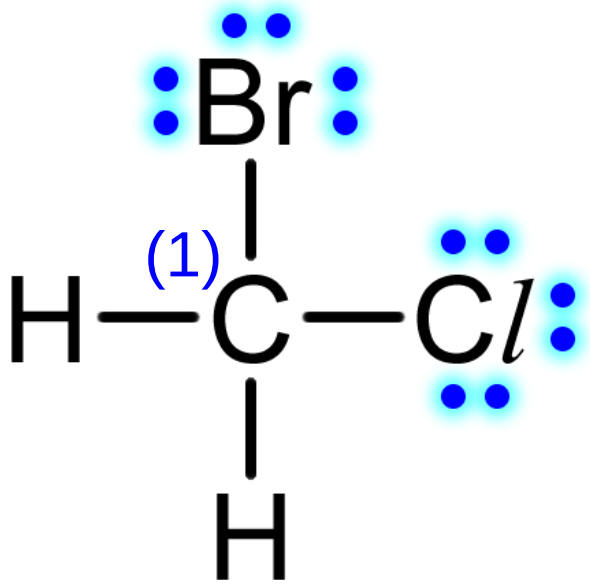


- Lewis Dot Diagram

- Number of sigma bonds = 4
- Number of pi bonds = 0
- Number of lone pair electrons = 6

Intermolecular Forces of Attraction and Shapes of Molecules

2. Bromochloromethane

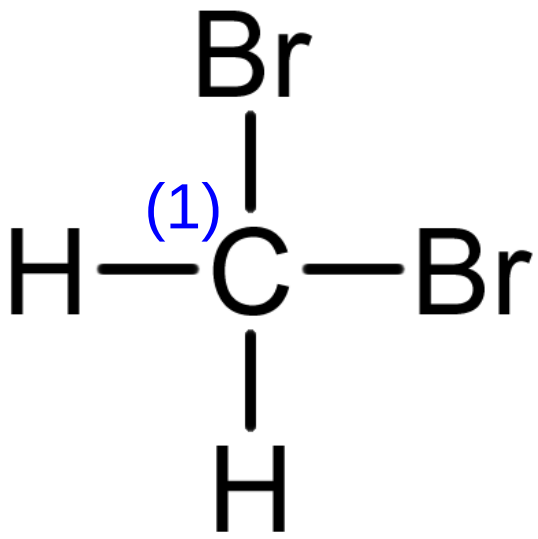


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Permanent dipole-permanent-dipole interactions

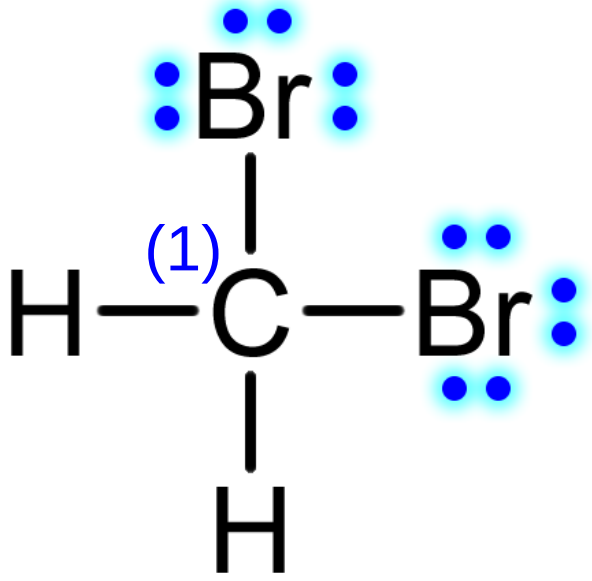
Intermolecular Forces of Attraction and Shapes of Molecules

3. Dibromomethane



Intermolecular Forces of Attraction and Shapes of Molecules

3. Dibromomethane

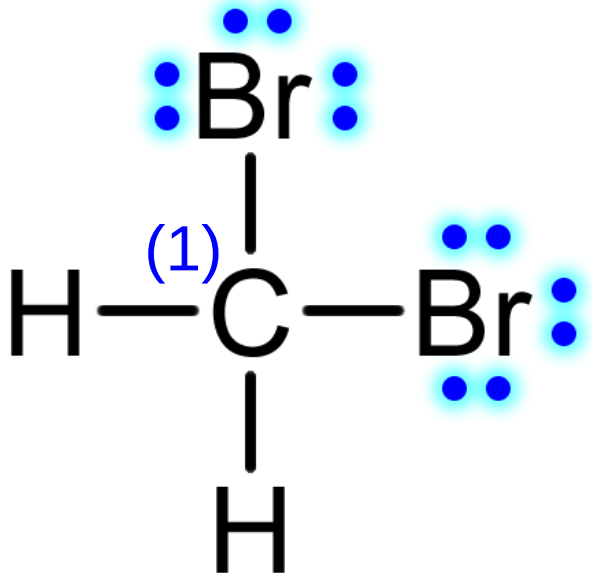


- Lewis Dot Diagram

- Number of sigma bonds = 4
- Number of pi bonds = 0
- Number of lone pair electrons = 6

Intermolecular Forces of Attraction and Shapes of Molecules

3. Dibromomethane

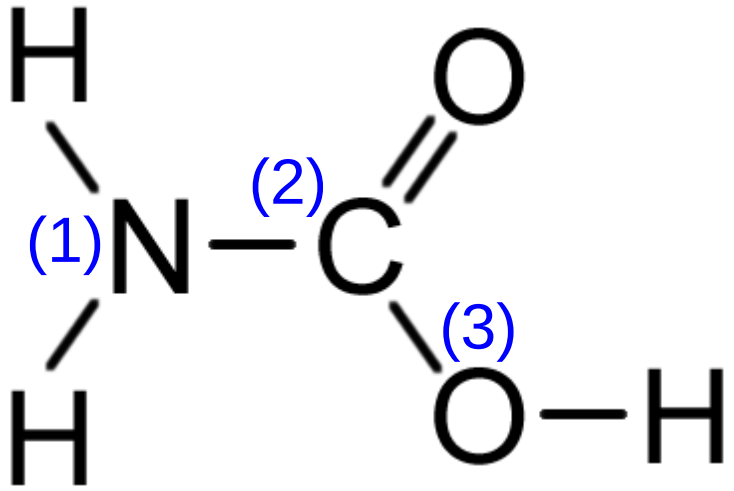


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

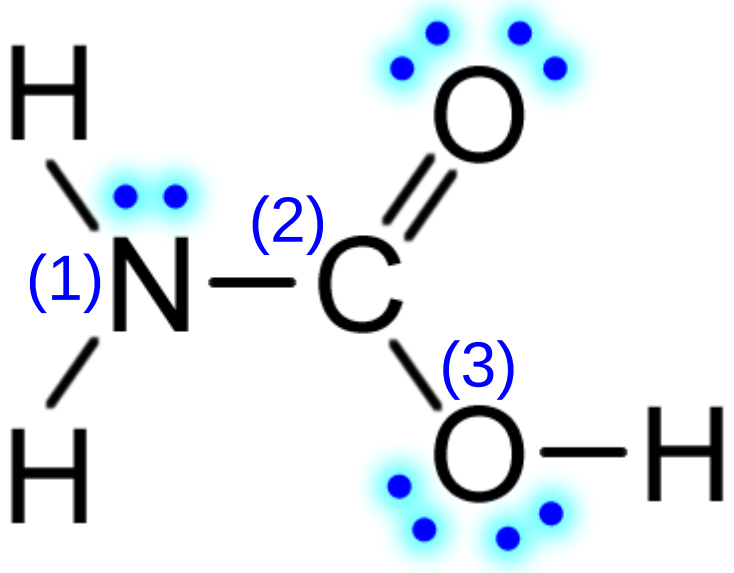
Intermolecular Forces of Attraction and Shapes of Molecules

4. Carbamic Acid



Intermolecular Forces of Attraction and Shapes of Molecules

4. Carbamic Acid

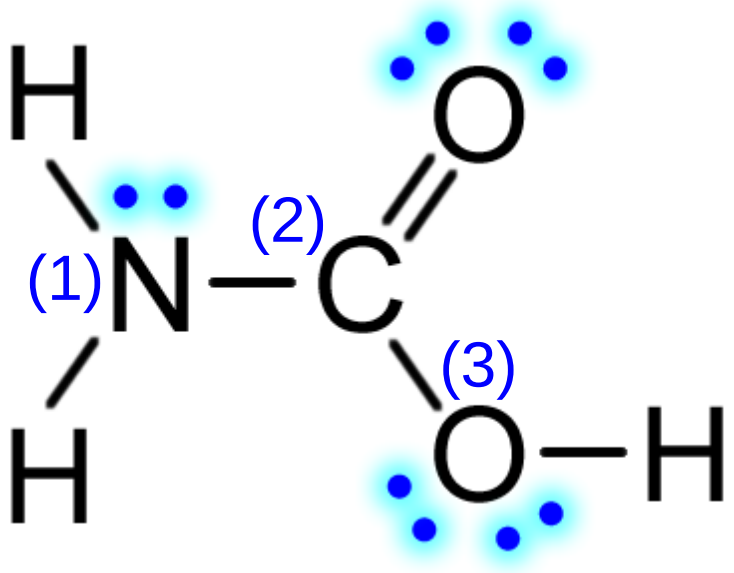


- Lewis Dot Diagram

- Number of sigma bonds = 6
- Number of pi bonds = 1
- Number of lone pair electrons = 5

Intermolecular Forces of Attraction and Shapes of Molecules

4. Carbamic Acid



- Lewis Dot Diagram

- Shape around nitrogen (1) = Trigonal pyramidal
- Shape around carbon (2) = Trigonal planar
- Shape around oxygen (3) = Angular
- Intermolecular force of attraction = Hydrogen bonding

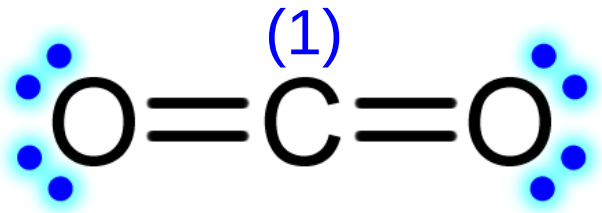
Intermolecular Forces of Attraction and Shapes of Molecules

5. Carbon Dioxide

(1)

Intermolecular Forces of Attraction and Shapes of Molecules

5. Carbon Dioxide

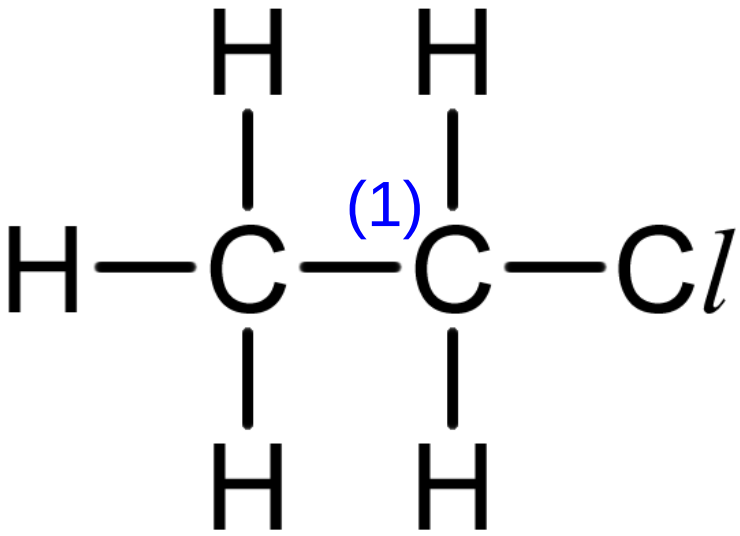


- Lewis Dot Diagram

- Number of sigma bonds = 2
- Number of pi bonds = 2
- Number of lone pair electrons = 4
- Shape around carbon (1) = Linear
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces (due to molecule's symmetry)

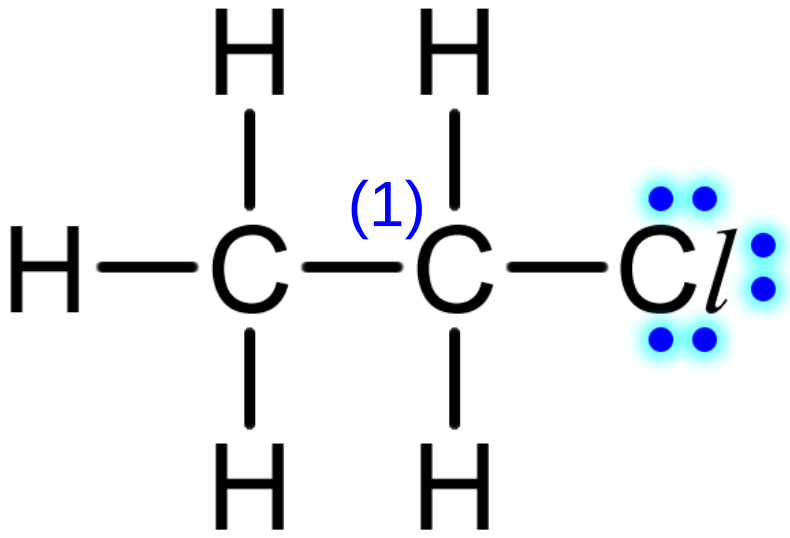
Intermolecular Forces of Attraction and Shapes of Molecules

6. Chloroethane



Intermolecular Forces of Attraction and Shapes of Molecules

6. Chloroethane

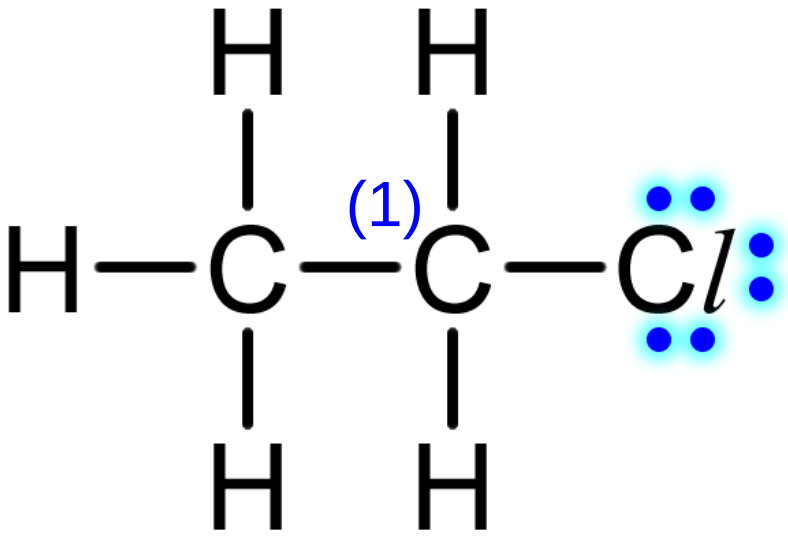


- Lewis Dot Diagram

- Number of sigma bonds = 7
- Number of pi bonds = 0
- Number of lone pair electrons = 3

Intermolecular Forces of Attraction and Shapes of Molecules

6. Chloroethane

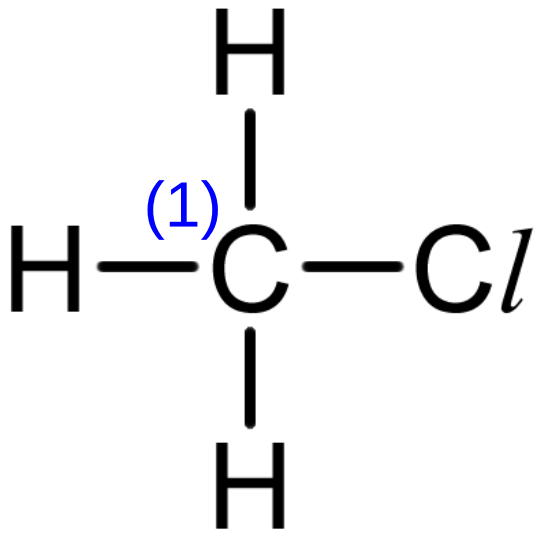


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Permanent dipole-permanent dipole interactions

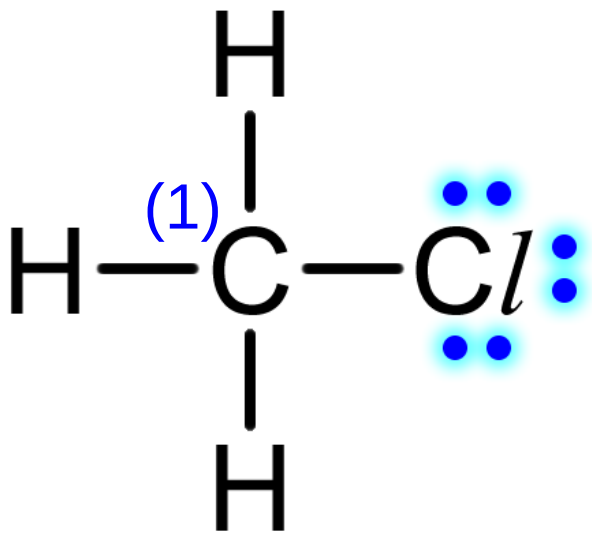
Intermolecular Forces of Attraction and Shapes of Molecules

7. Chloromethane



Intermolecular Forces of Attraction and Shapes of Molecules

7. Chloromethane

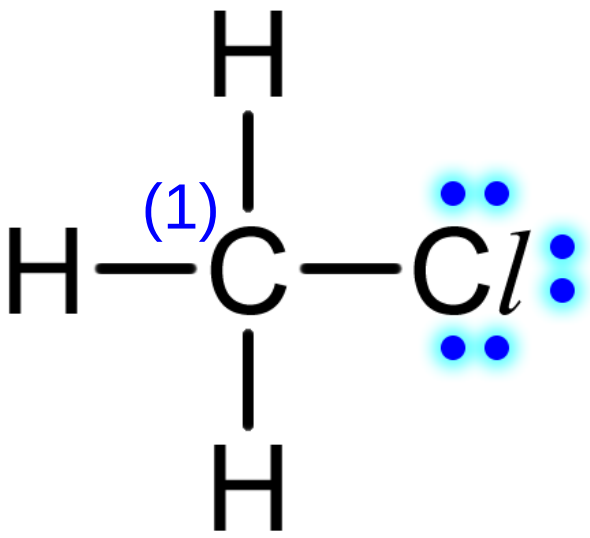


- Lewis Dot Diagram

- Number of sigma bonds = 4
- Number of pi bonds = 0
- Number of lone pair electrons = 3

Intermolecular Forces of Attraction and Shapes of Molecules

7. Chloromethane

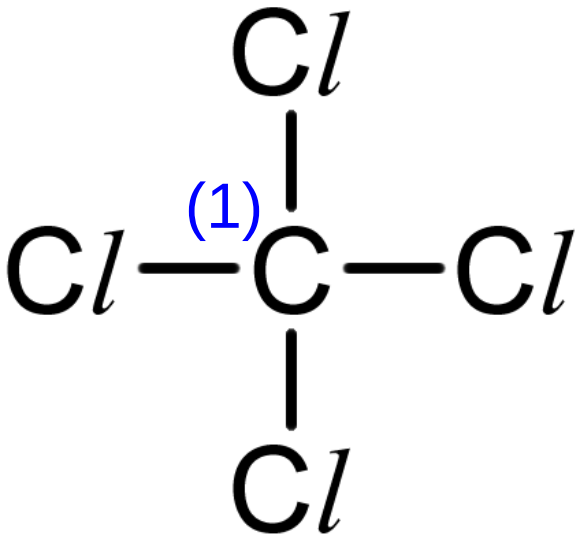


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Permanent dipole-permanent dipole interactions

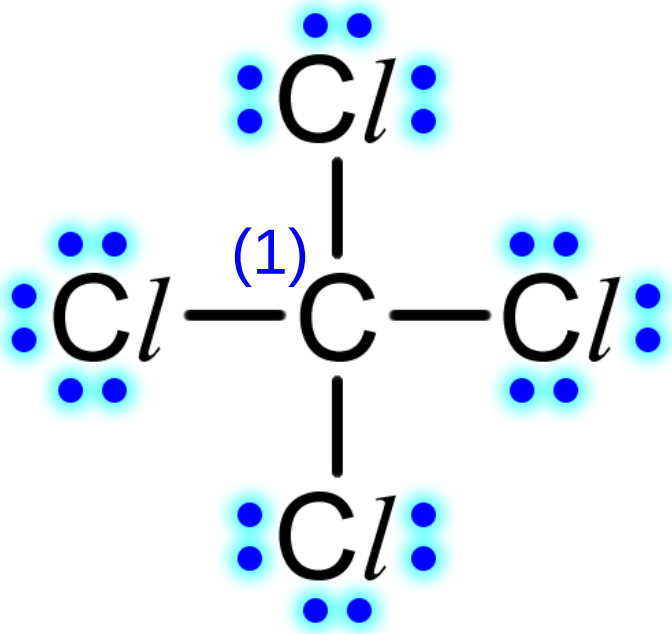
Intermolecular Forces of Attraction and Shapes of Molecules

8. Tetrachloromethane



Intermolecular Forces of Attraction and Shapes of Molecules

8. Tetrachloromethane

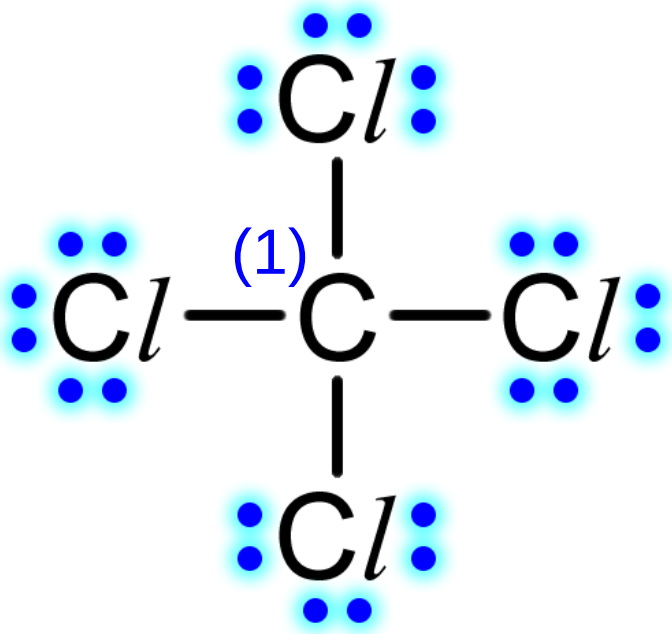


- Lewis Dot Diagram

- Number of sigma bonds = 4
- Number of pi bonds = 0
- Number of lone pair electrons = 12

Intermolecular Forces of Attraction and Shapes of Molecules

8. Tetrachloromethane

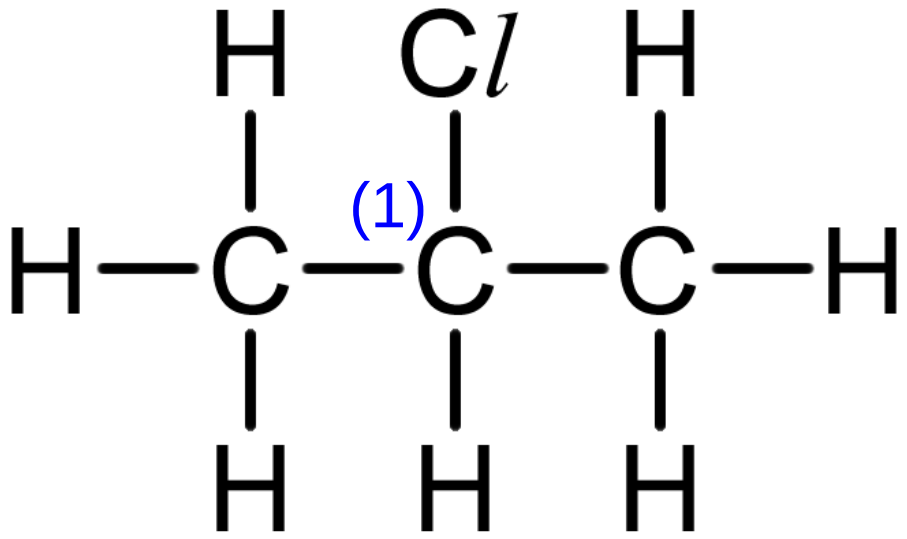


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces (due to molecule's symmetry)

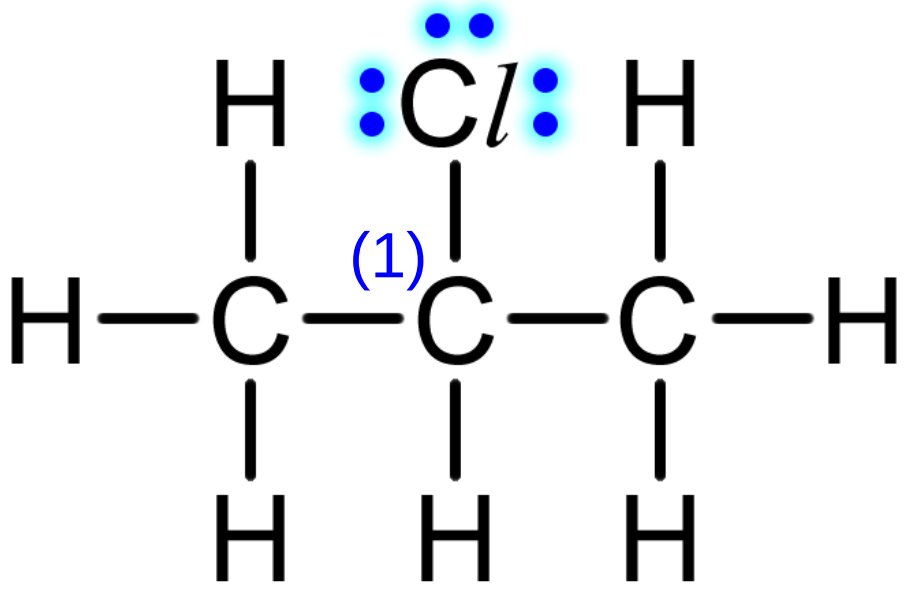
Intermolecular Forces of Attraction and Shapes of Molecules

9. 2-Chloropropane



Intermolecular Forces of Attraction and Shapes of Molecules

9. 2-Chloropropane

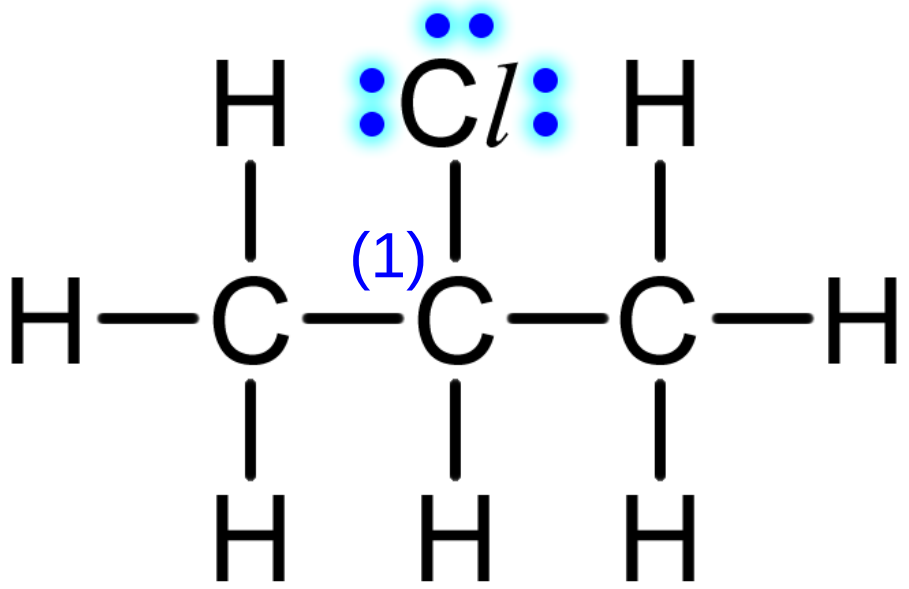


- Lewis Dot Diagram

- Number of sigma bonds = 10
- Number of pi bonds = 0
- Number of lone pair electrons = 3

Intermolecular Forces of Attraction and Shapes of Molecules

9. 2-Chloropropane

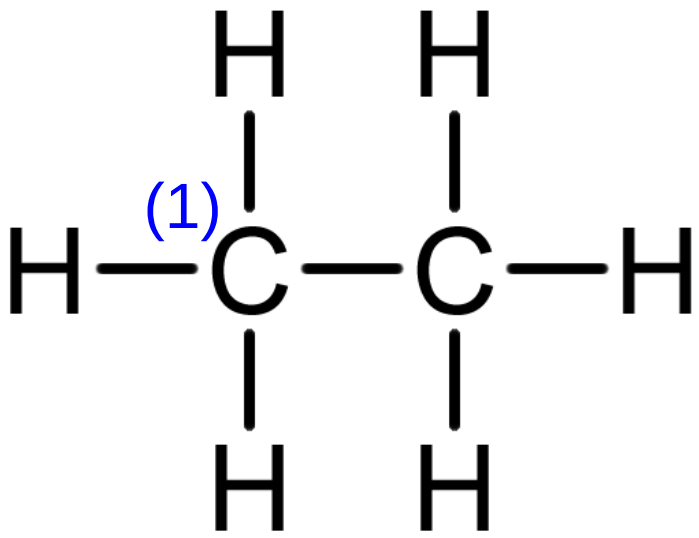


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Permanent dipole-permanent dipole interactions

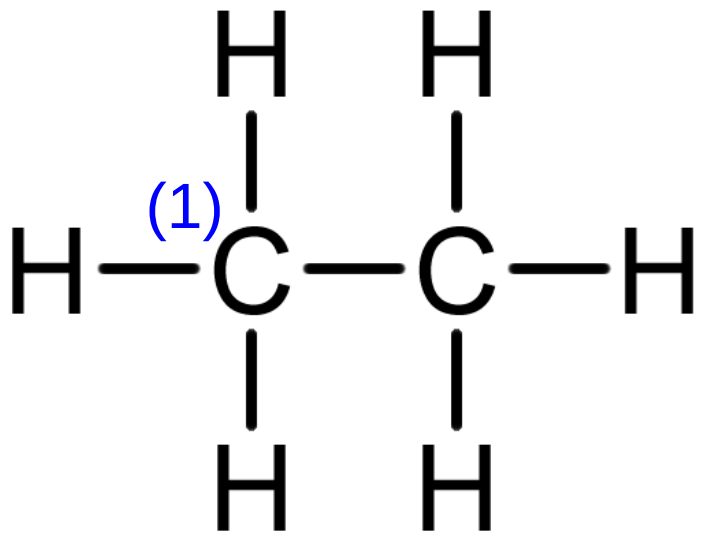
Intermolecular Forces of Attraction and Shapes of Molecules

10. Ethane



Intermolecular Forces of Attraction and Shapes of Molecules

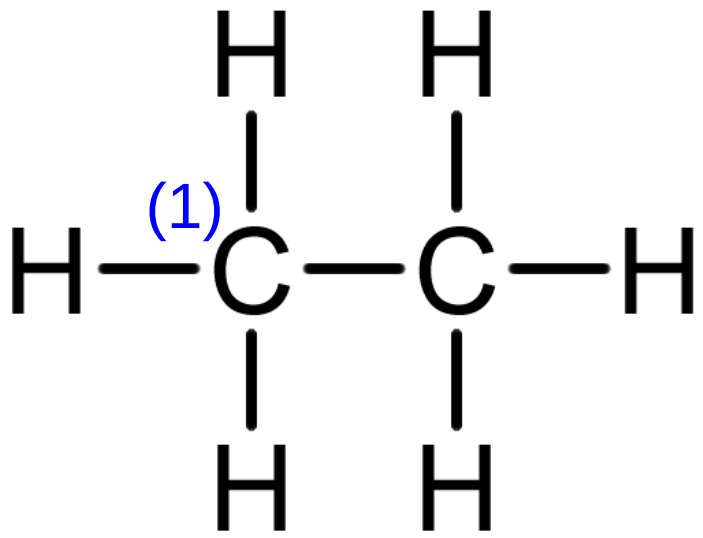
10. Ethane



- Number of sigma bonds = 7
- Number of pi bonds = 0
- Number of lone pair electrons = 0

Intermolecular Forces of Attraction and Shapes of Molecules

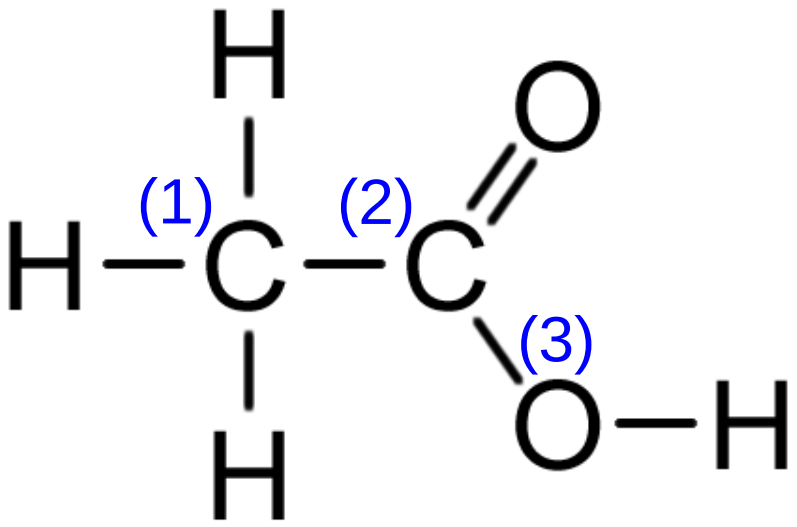
10. Ethane



- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

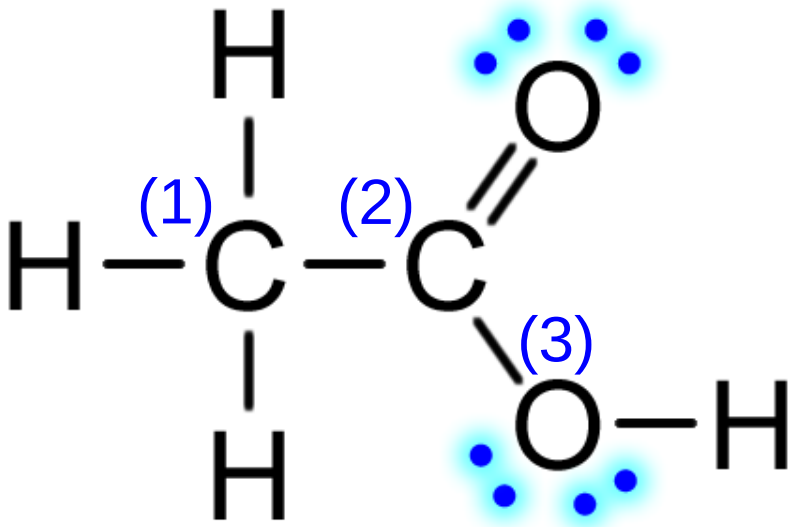
Intermolecular Forces of Attraction and Shapes of Molecules

11. Ethanoic Acid



Intermolecular Forces of Attraction and Shapes of Molecules

11. Ethanoic Acid

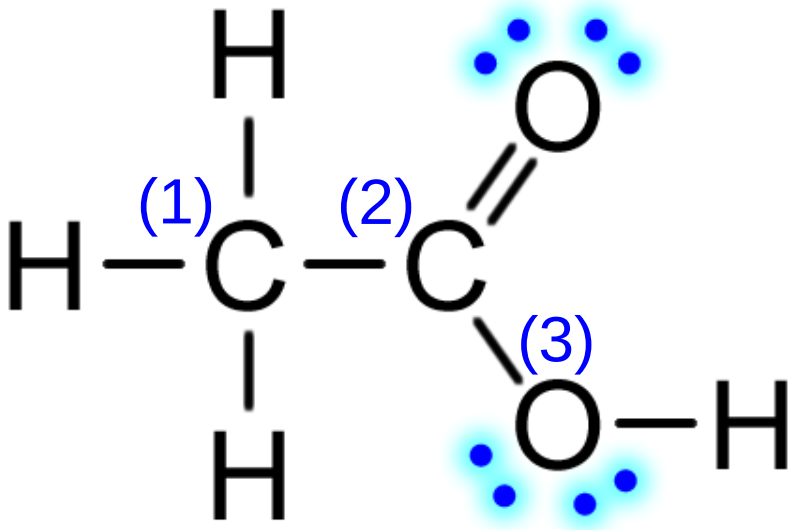


- Lewis Dot Diagram

- Number of sigma bonds = 7
- Number of pi bonds = 1
- Number of lone pair electrons = 4

Intermolecular Forces of Attraction and Shapes of Molecules

11. Ethanoic Acid

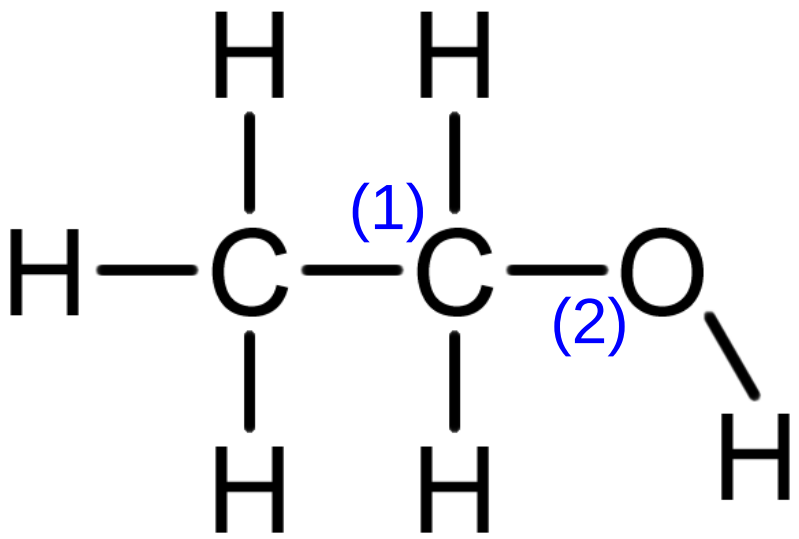


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Shape around carbon (2) = Trigonal planar
- Shape around oxygen (3) = Angular
- Intermolecular force of attraction = Hydrogen bonding

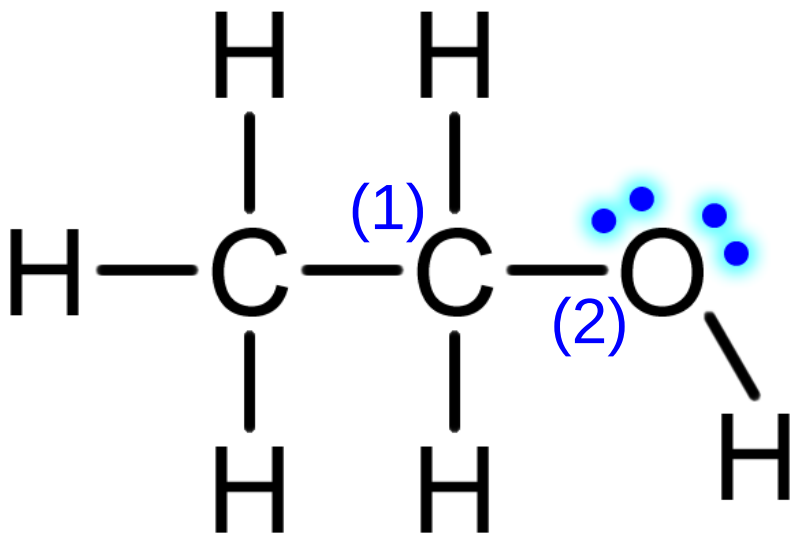
Intermolecular Forces of Attraction and Shapes of Molecules

12. Ethanol



Intermolecular Forces of Attraction and Shapes of Molecules

12. Ethanol

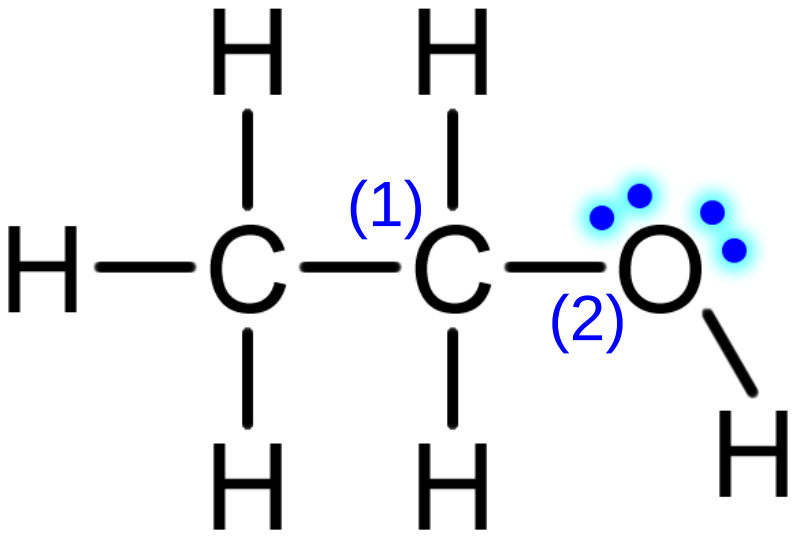


- Lewis Dot Diagram

- Number of sigma bonds = 8
- Number of pi bonds = 0
- Number of lone pair electrons = 2

Intermolecular Forces of Attraction and Shapes of Molecules

12. Ethanol

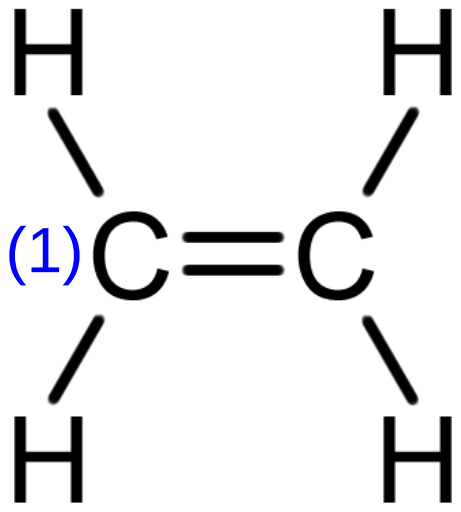


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Shape around oxygen (2) = Angular
- Intermolecular force of attraction = Hydrogen bonding

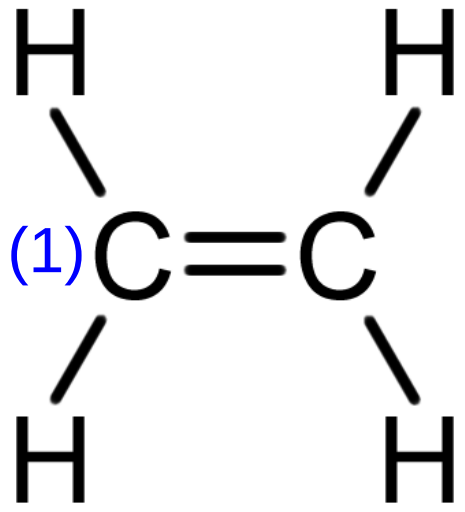
Intermolecular Forces of Attraction and Shapes of Molecules

13. Ethene



Intermolecular Forces of Attraction and Shapes of Molecules

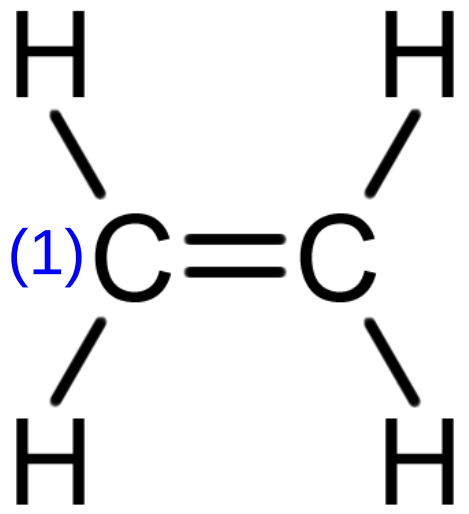
13. Ethene



- Number of sigma bonds = 5
- Number of pi bonds = 1
- Number of lone pair electrons = 0

Intermolecular Forces of Attraction and Shapes of Molecules

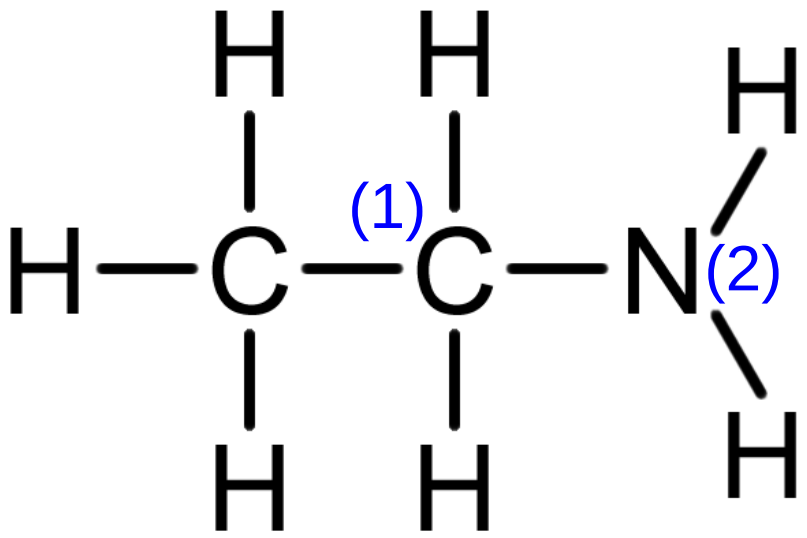
13. Ethene



- Shape around carbon (1) = Trigonal planar
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

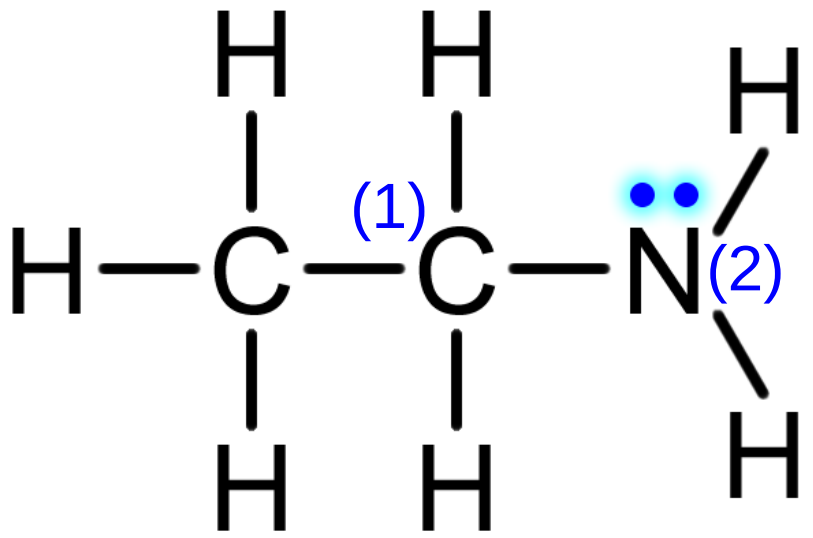
Intermolecular Forces of Attraction and Shapes of Molecules

14. Ethylamine



Intermolecular Forces of Attraction and Shapes of Molecules

14. Ethylamine

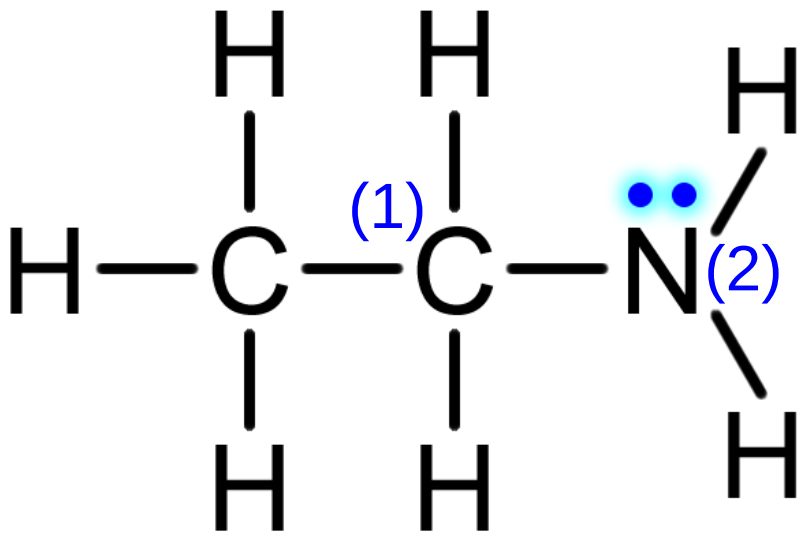


- Lewis Dot Diagram

- Number of sigma bonds = 9
- Number of pi bonds = 0
- Number of lone pair electrons = 1

Intermolecular Forces of Attraction and Shapes of Molecules

14. Ethylamine

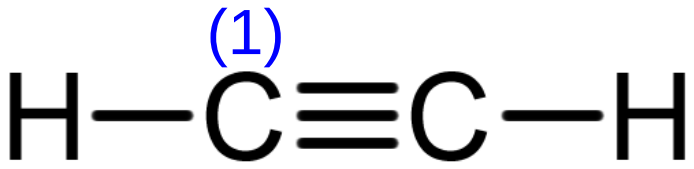


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Shape around nitrogen (2) = Trigonal pyramidal
- Intermolecular force of attraction = Hydrogen bonding

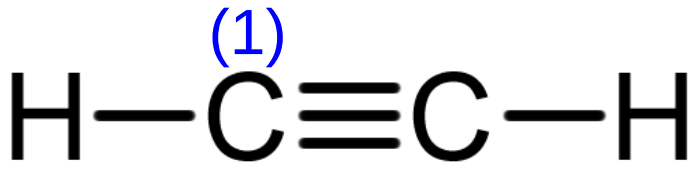
Intermolecular Forces of Attraction and Shapes of Molecules

15. Ethyne



Intermolecular Forces of Attraction and Shapes of Molecules

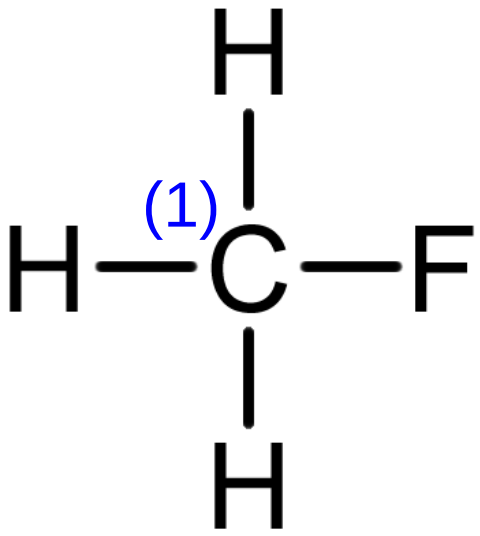
15. Ethyne



- Number of sigma bonds = 3
- Number of pi bonds = 2
- Number of lone pair electrons = 0
- Shape around carbon (1) = Linear
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

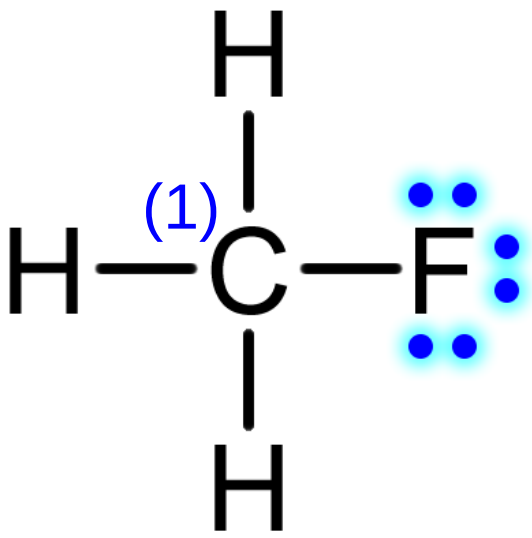
Intermolecular Forces of Attraction and Shapes of Molecules

16. Fluoromethane



Intermolecular Forces of Attraction and Shapes of Molecules

16. Fluoromethane

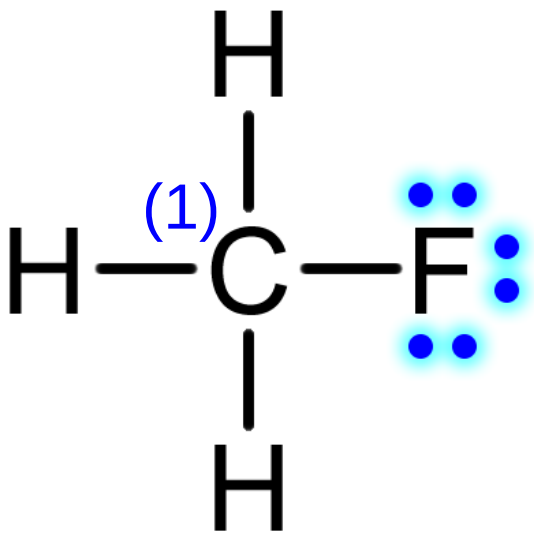


- Lewis Dot Diagram

- Number of sigma bonds = 4
- Number of pi bonds = 0
- Number of lone pair electrons = 3

Intermolecular Forces of Attraction and Shapes of Molecules

16. Fluoromethane

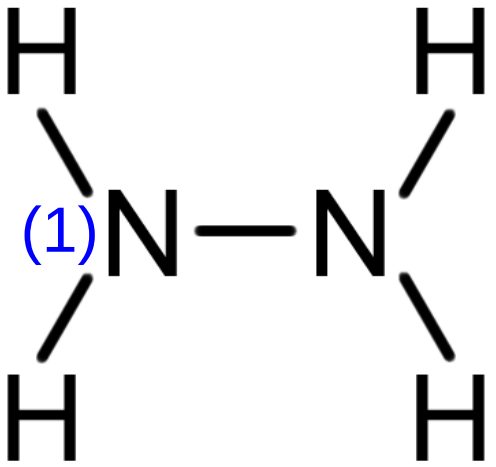


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Permanent dipole-permanent dipole interactions

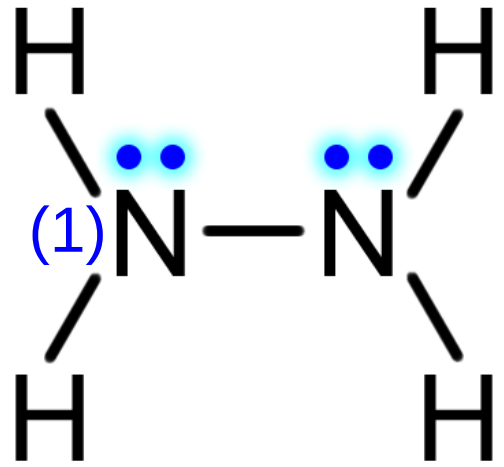
Intermolecular Forces of Attraction and Shapes of Molecules

17. Hydrazine



Intermolecular Forces of Attraction and Shapes of Molecules

17. Hydrazine



- Lewis Dot Diagram

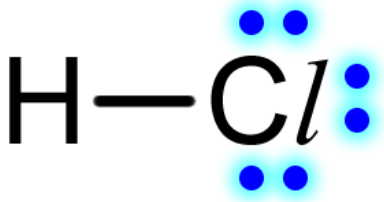
- Number of sigma bonds = 5
- Number of pi bonds = 0
- Number of lone pair electrons = 2
- Shape around nitrogen (1) = Trigonal pyramidal
- Intermolecular force of attraction = Hydrogen bonding

Intermolecular Forces of Attraction and Shapes of Molecules

18. Hydrogen Chloride

Intermolecular Forces of Attraction and Shapes of Molecules

18. Hydrogen Chloride



- Lewis Dot Diagram

- Number of sigma bonds = 1
- Number of pi bonds = 0
- Number of lone pair electrons = 3
- Shape of molecule = Linear
- Intermolecular force of attraction = Permanent dipole-permanent dipole interactions

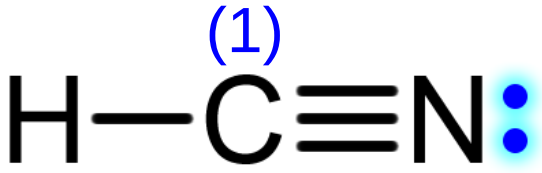
Intermolecular Forces of Attraction and Shapes of Molecules

19. Hydrogen Cyanide

(1)

Intermolecular Forces of Attraction and Shapes of Molecules

19. Hydrogen Cyanide



- Lewis Dot Diagram

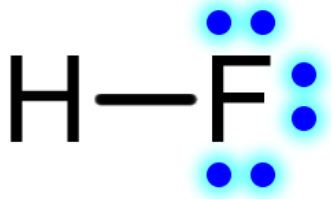
- Number of sigma bonds = 2
- Number of pi bonds = 2
- Number of lone pair electrons = 1
- Shape around carbon (1) = Linear
- Intermolecular force of attraction = Permanent dipole-permanent dipole interactions

Intermolecular Forces of Attraction and Shapes of Molecules

20. Hydrogen Fluoride

Intermolecular Forces of Attraction and Shapes of Molecules

20. Hydrogen Fluoride

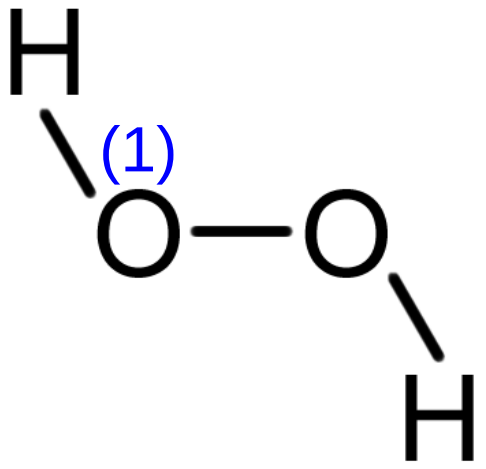


- Lewis Dot Diagram

- Number of sigma bonds = 1
- Number of pi bonds = 0
- Number of lone pair electrons = 3
- Shape of molecule = Linear
- Intermolecular force of attraction = Hydrogen bonding

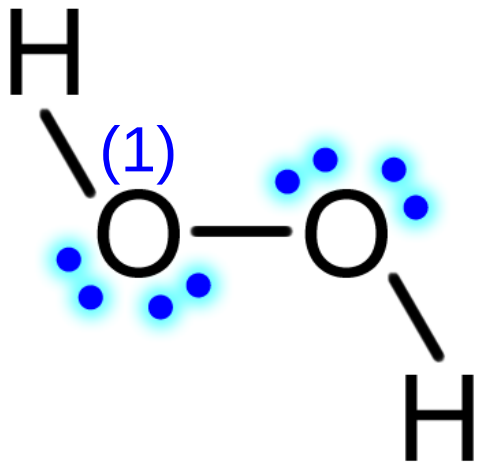
Intermolecular Forces of Attraction and Shapes of Molecules

21. Hydrogen Peroxide



Intermolecular Forces of Attraction and Shapes of Molecules

21. Hydrogen Peroxide

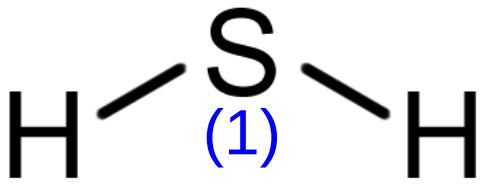


- Lewis Dot Diagram

- Number of sigma bonds = 3
- Number of pi bonds = 0
- Number of lone pair electrons = 4
- Shape around oxygen (1) = Angular
- Intermolecular force of attraction = Hydrogen bonding

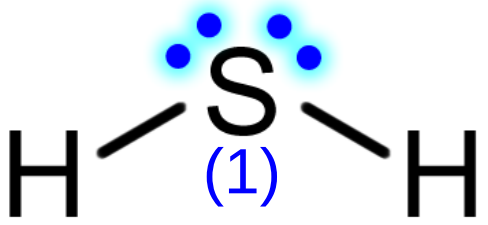
Intermolecular Forces of Attraction and Shapes of Molecules

22. Hydrogen Sulfide



Intermolecular Forces of Attraction and Shapes of Molecules

22. Hydrogen Sulfide

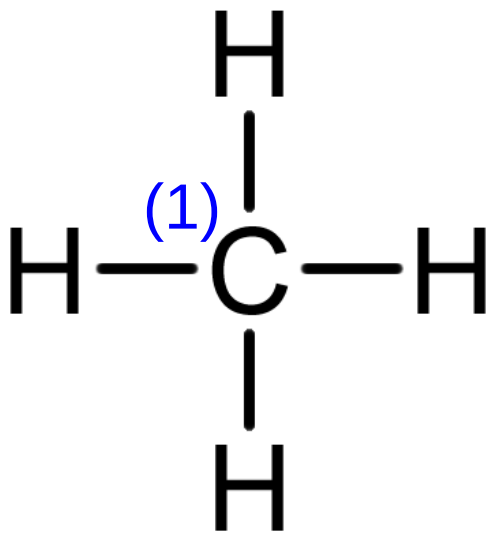


- Lewis Dot Diagram

- Number of sigma bonds = 2
- Number of pi bonds = 0
- Number of lone pair electrons = 2
- Shape around sulfur (1) = Angular
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

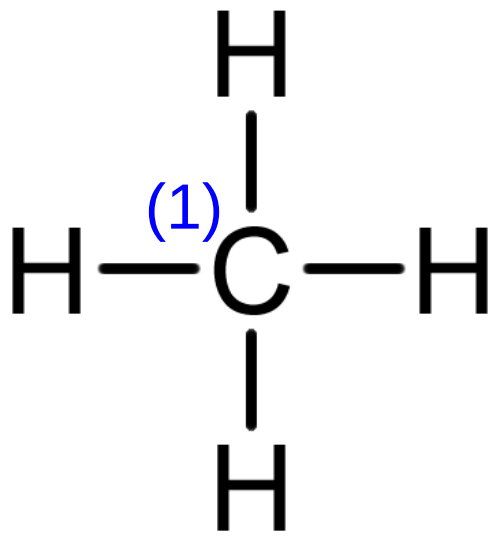
Intermolecular Forces of Attraction and Shapes of Molecules

23. Methane



Intermolecular Forces of Attraction and Shapes of Molecules

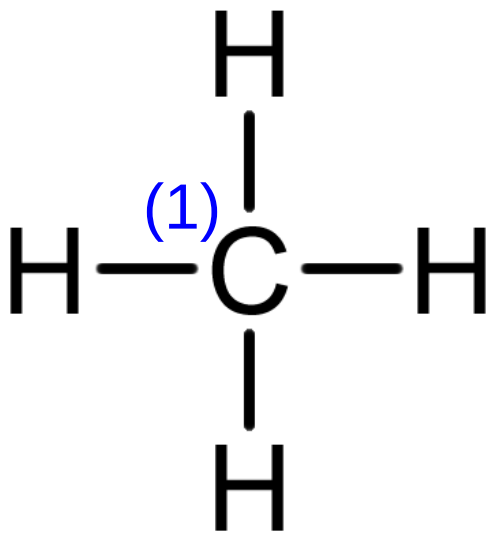
23. Methane



- Number of sigma bonds = 4
- Number of pi bonds = 0
- Number of lone pair electrons = 0

Intermolecular Forces of Attraction and Shapes of Molecules

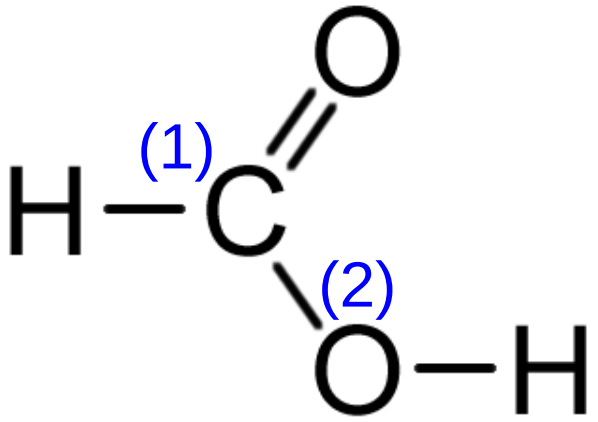
23. Methane



- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

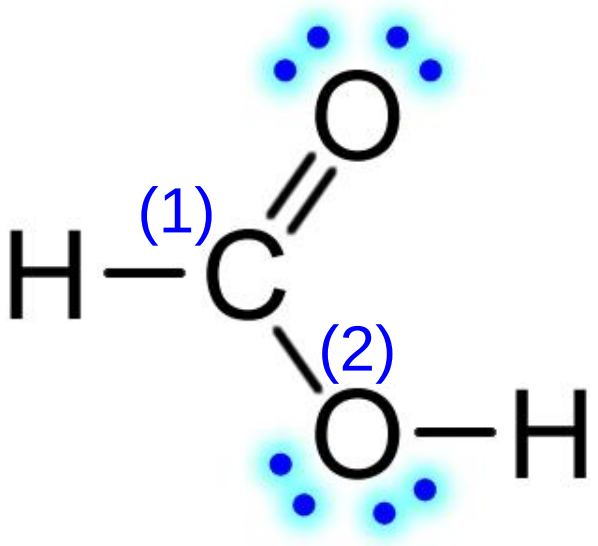
Intermolecular Forces of Attraction and Shapes of Molecules

24. Methanoic Acid



Intermolecular Forces of Attraction and Shapes of Molecules

24. Methanoic Acid

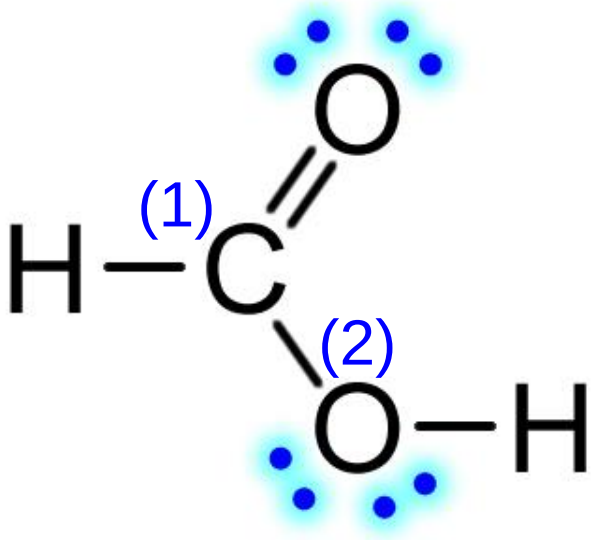


- Lewis Dot Diagram

- Number of sigma bonds = 4
- Number of pi bonds = 1
- Number of lone pair electrons = 4

Intermolecular Forces of Attraction and Shapes of Molecules

24. Methanoic Acid

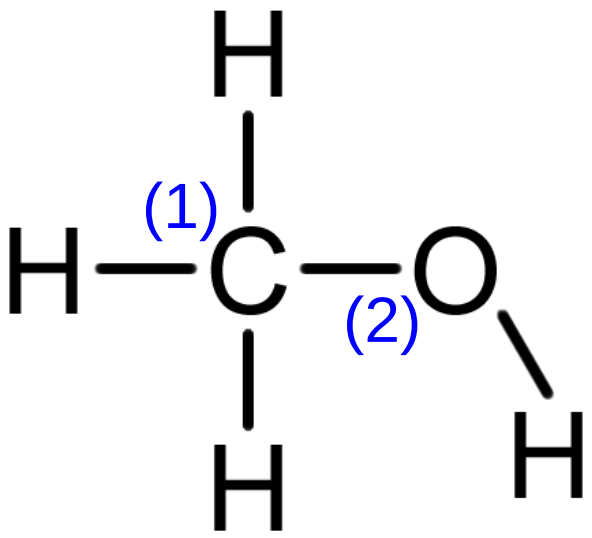


- Lewis Dot Diagram

- Shape around carbon (1) = Trigonal planar
- Shape around oxygen (2) = Angular
- Intermolecular force of attraction = Hydrogen bonding

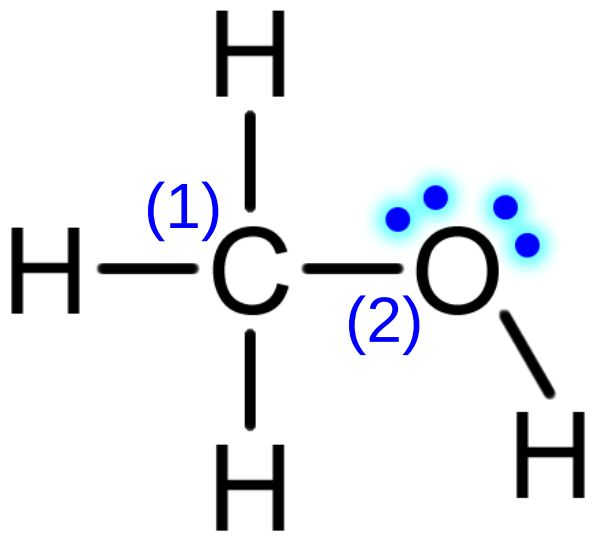
Intermolecular Forces of Attraction and Shapes of Molecules

25. Methanol



Intermolecular Forces of Attraction and Shapes of Molecules

25. Methanol

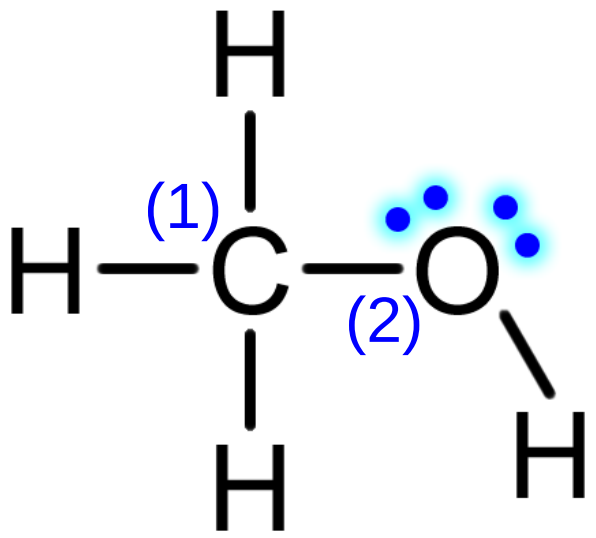


- Lewis Dot Diagram

- Number of sigma bonds = 5
- Number of pi bonds = 0
- Number of lone pair electrons = 2

Intermolecular Forces of Attraction and Shapes of Molecules

25. Methanol

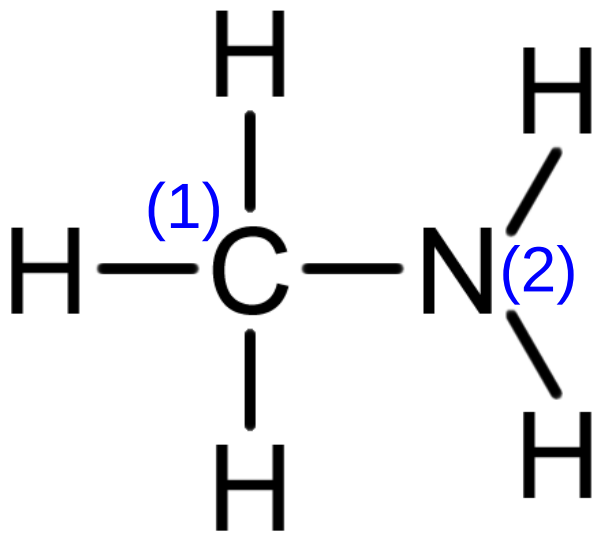


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Shape around oxygen (2) = Angular
- Intermolecular force of attraction = Hydrogen bonding

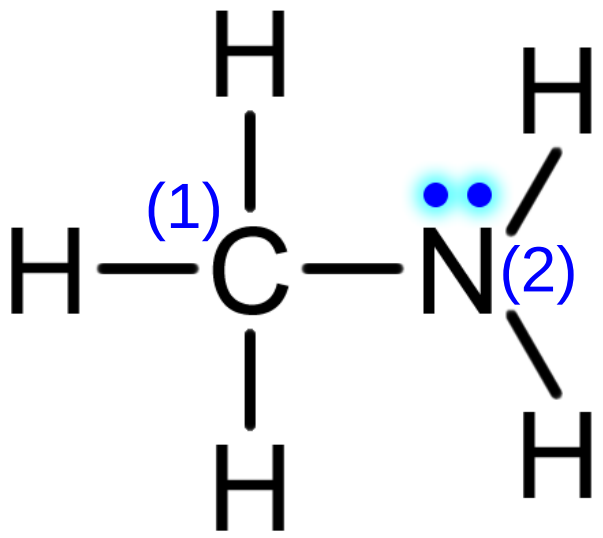
Intermolecular Forces of Attraction and Shapes of Molecules

26. Methylamine



Intermolecular Forces of Attraction and Shapes of Molecules

26. Methylamine

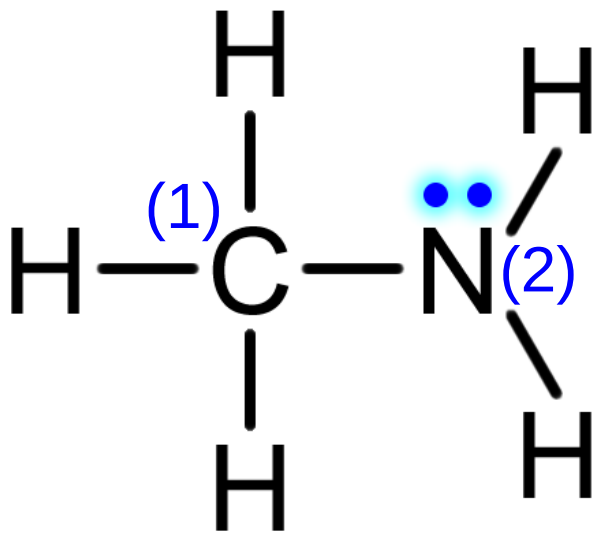


- Lewis Dot Diagram

- Number of sigma bonds = 6
- Number of pi bonds = 0
- Number of lone pair electrons = 1

Intermolecular Forces of Attraction and Shapes of Molecules

26. Methylamine

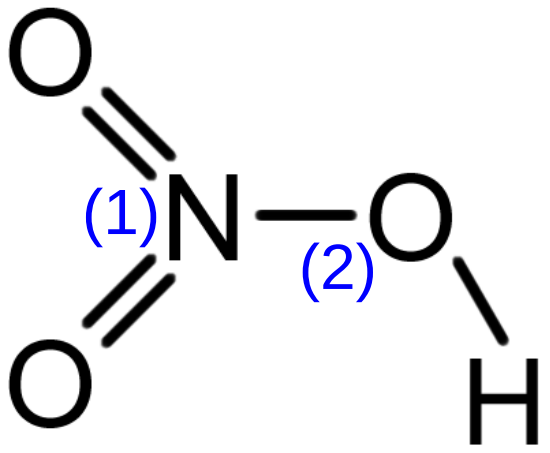


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Shape around nitrogen (2) = Trigonal pyramidal
- Intermolecular force of attraction = Hydrogen bonding

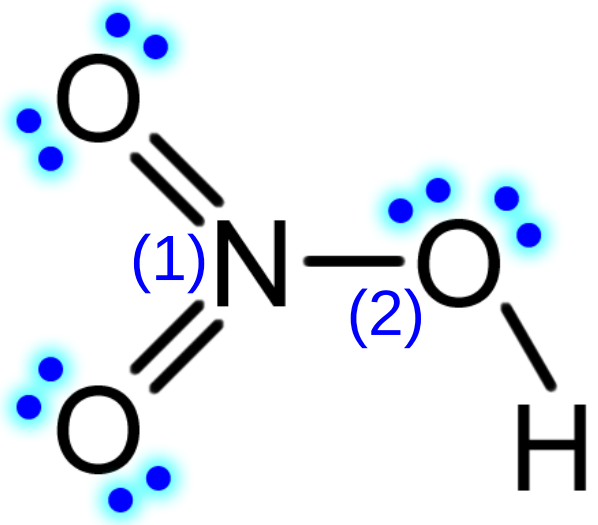
Intermolecular Forces of Attraction and Shapes of Molecules

27. Nitric Acid



Intermolecular Forces of Attraction and Shapes of Molecules

27. Nitric Acid

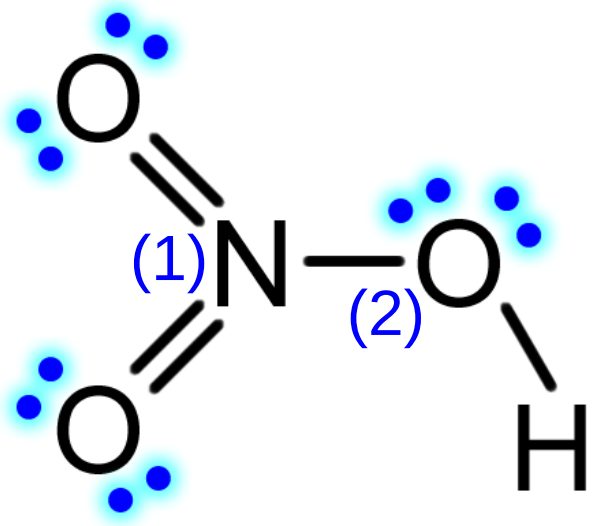


- Lewis Dot Diagram

- Number of sigma bonds = 4
- Number of pi bonds = 2
- Number of lone pair electrons = 6

Intermolecular Forces of Attraction and Shapes of Molecules

27. Nitric Acid



- Lewis Dot Diagram

- Shape around nitrogen (1) = Trigonal planar
- Shape around oxygen (2) = Angular
- Intermolecular force of attraction = Hydrogen bonding

Intermolecular Forces of Attraction and Shapes of Molecules

28. Nitrogen

Intermolecular Forces of Attraction and Shapes of Molecules

28. Nitrogen

- Lewis Dot Diagram

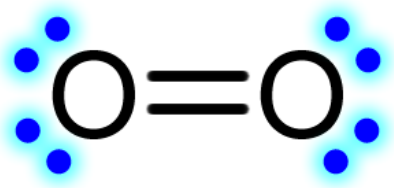
- Number of sigma bonds = 1
- Number of pi bonds = 2
- Number of lone pair electrons = 2
- Shape of molecule = Linear
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

Intermolecular Forces of Attraction and Shapes of Molecules

29. Oxygen

Intermolecular Forces of Attraction and Shapes of Molecules

29. Oxygen

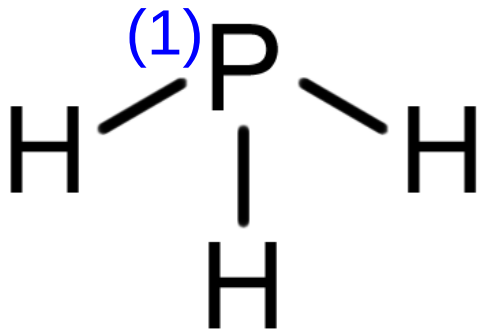


- Lewis Dot Diagram

- Number of sigma bonds = 1
- Number of pi bonds = 1
- Number of lone pair electrons = 4
- Shape of molecule = Linear
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

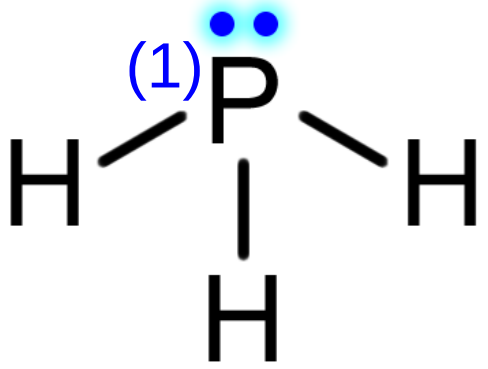
Intermolecular Forces of Attraction and Shapes of Molecules

30. Phosphine



Intermolecular Forces of Attraction and Shapes of Molecules

30. Phosphine

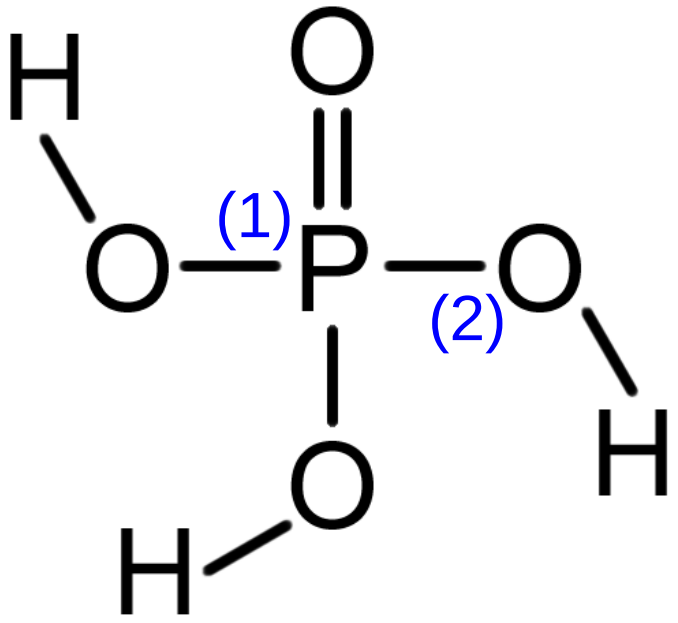


- Lewis Dot Diagram

- Number of sigma bonds = 3
- Number of pi bonds = 0
- Number of lone pair electrons = 1
- Shape around phosphorus (1) = Trigonal pyramidal
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

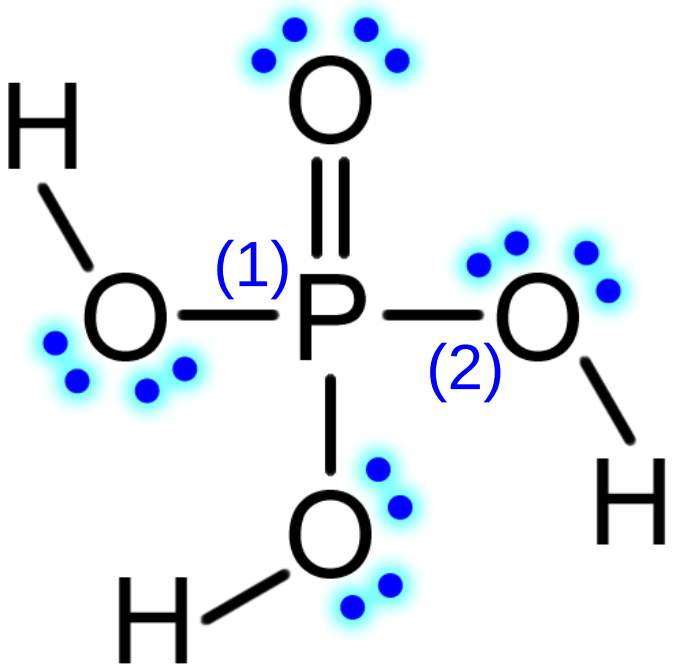
Intermolecular Forces of Attraction and Shapes of Molecules

31. Phosphoric Acid



Intermolecular Forces of Attraction and Shapes of Molecules

31. Phosphoric Acid

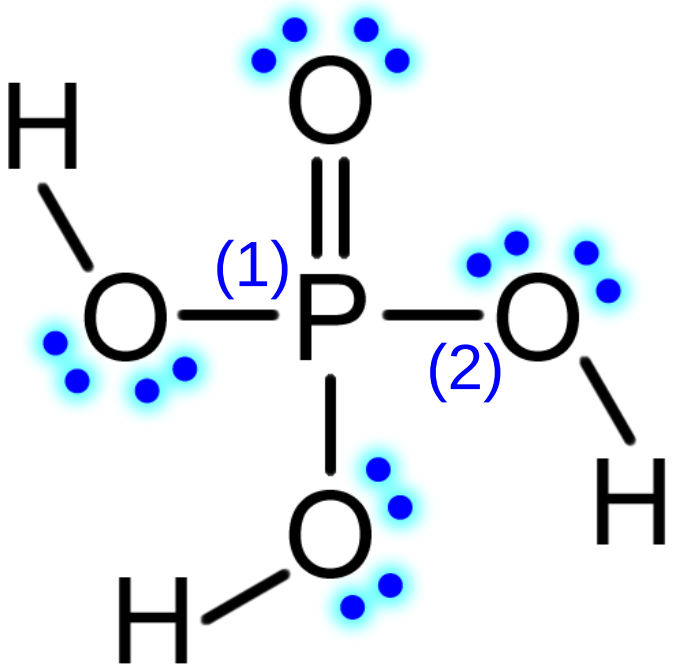


- Lewis Dot Diagram

- Number of sigma bonds = 7
- Number of pi bonds = 1
- Number of lone pair electrons = 8

Intermolecular Forces of Attraction and Shapes of Molecules

31. Phosphoric Acid

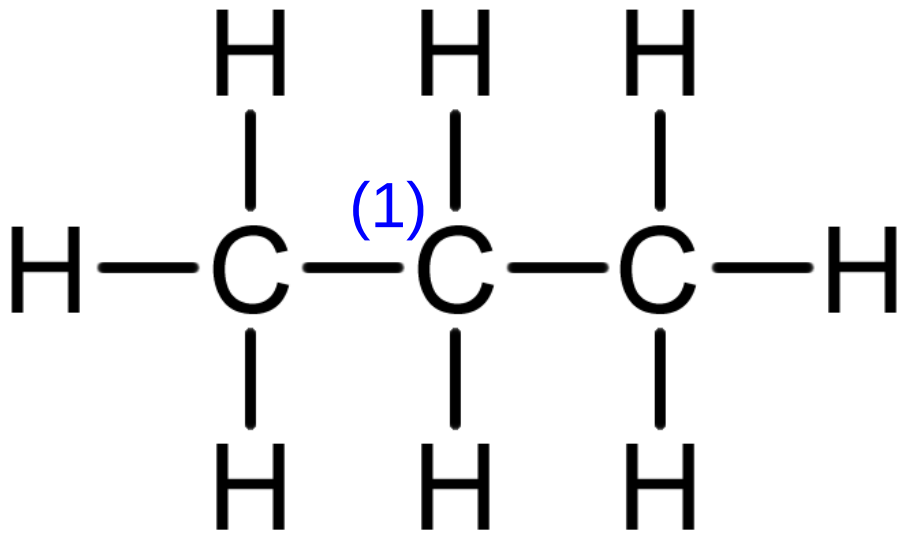


- Lewis Dot Diagram

- Shape around phosphorus (1) = Tetrahedral
- Shape around oxygen (2) = Angular
- Intermolecular force of attraction = Hydrogen bonding

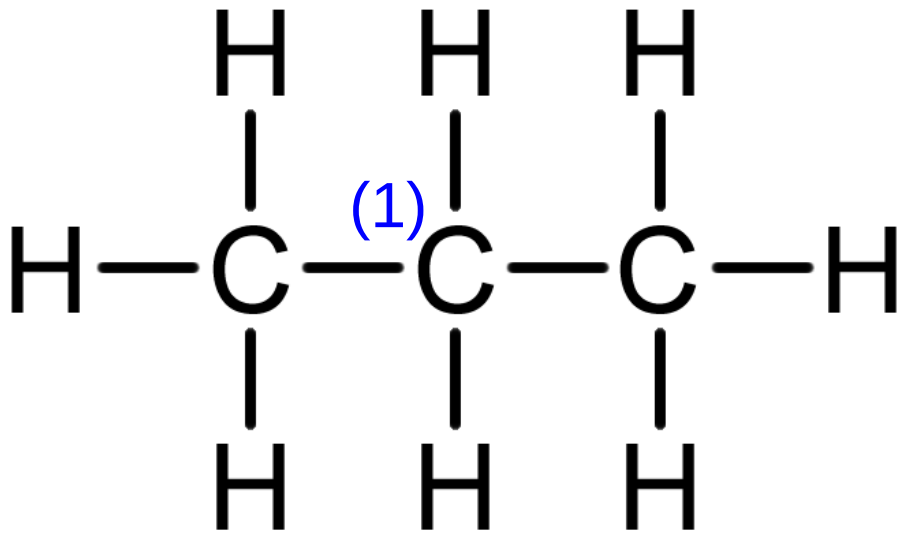
Intermolecular Forces of Attraction and Shapes of Molecules

32. Propane



Intermolecular Forces of Attraction and Shapes of Molecules

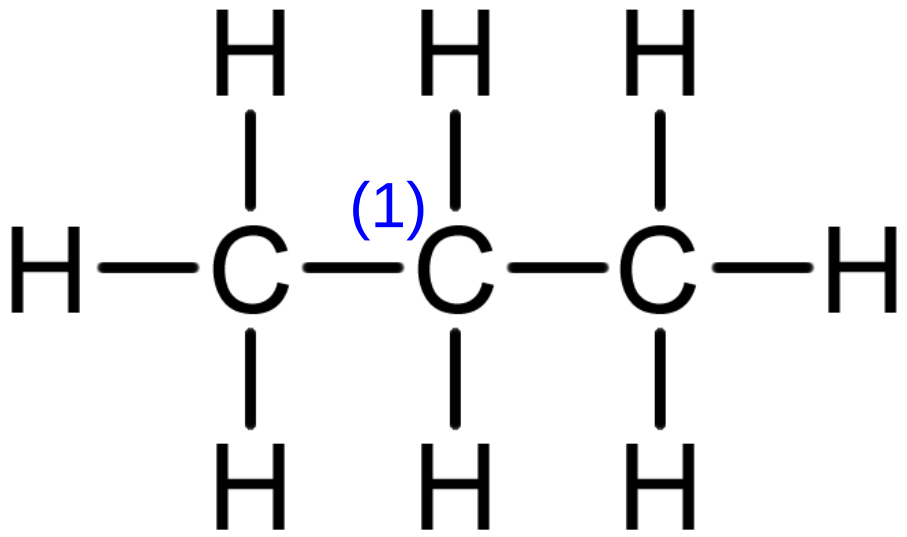
32. Propane



- Number of sigma bonds = 10
- Number of pi bonds = 0
- Number of lone pair electrons = 0

Intermolecular Forces of Attraction and Shapes of Molecules

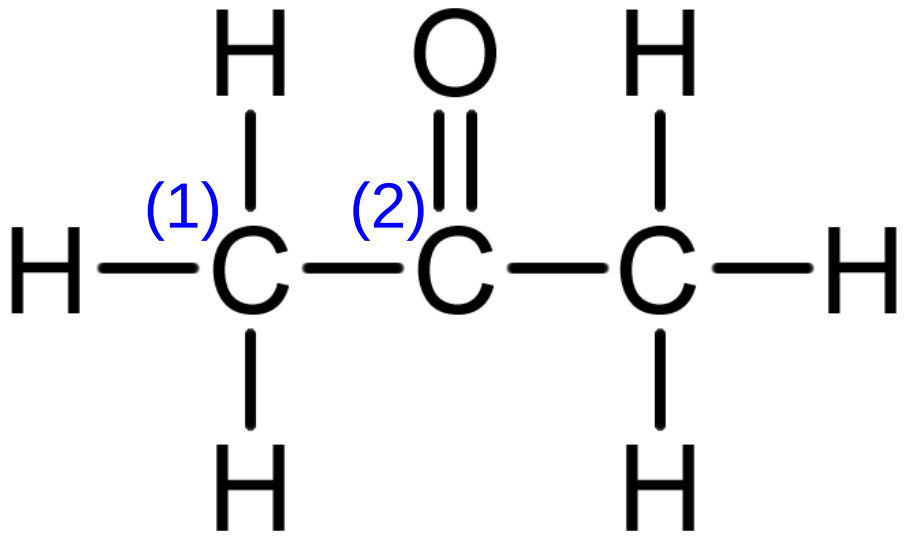
32. Propane



- Shape around carbon (1) = Tetrahedral
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

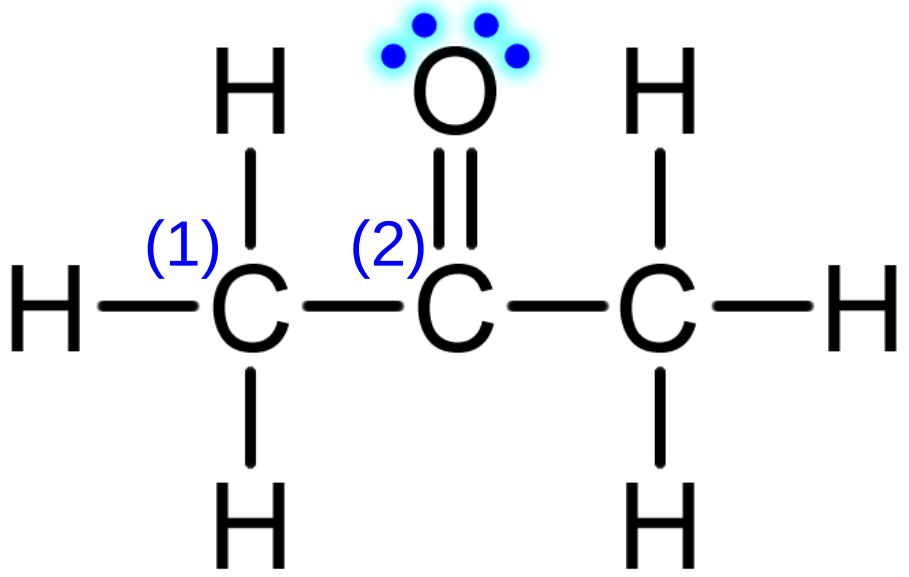
Intermolecular Forces of Attraction and Shapes of Molecules

33. Propanone



Intermolecular Forces of Attraction and Shapes of Molecules

33. Propanone

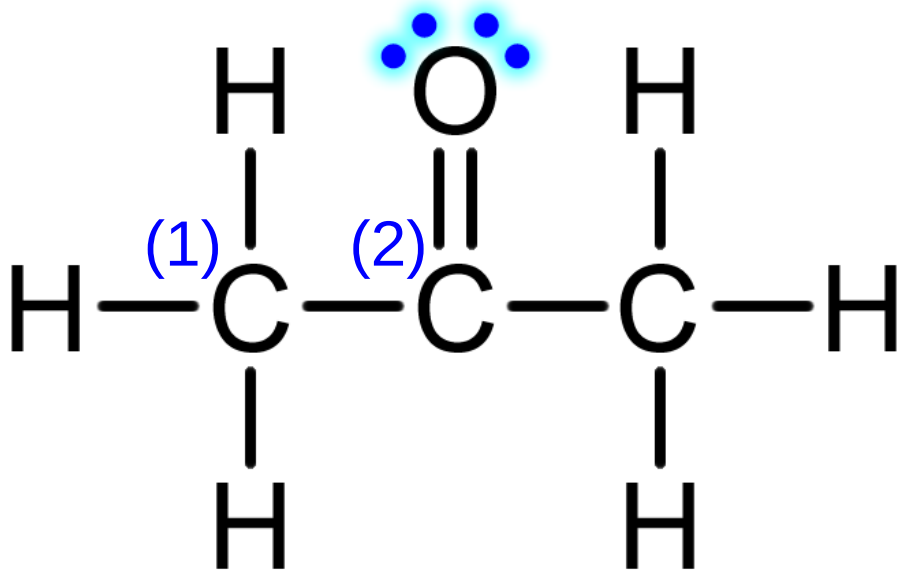


- Lewis Dot Diagram

- Number of sigma bonds = 9
- Number of pi bonds = 1
- Number of lone pair electrons = 2

Intermolecular Forces of Attraction and Shapes of Molecules

33. Propanone

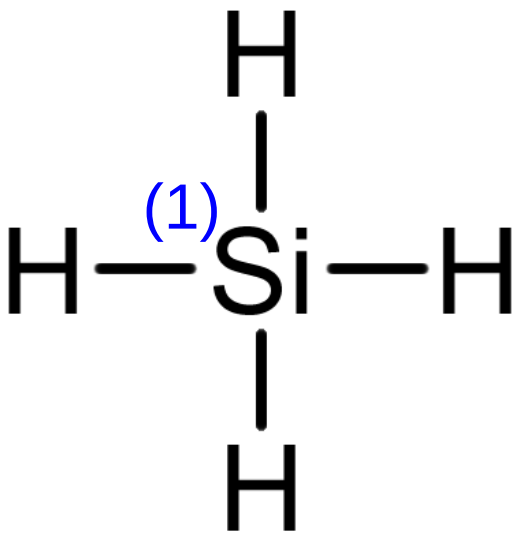


- Lewis Dot Diagram

- Shape around carbon (1) = Tetrahedral
- Shape around carbon (2) = Trigonal planar
- Intermolecular force of attraction = Permanent dipole-permanent dipole interactions

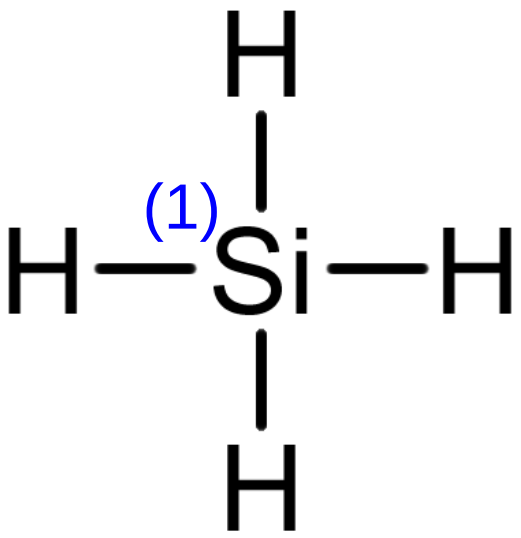
Intermolecular Forces of Attraction and Shapes of Molecules

34. Silane



Intermolecular Forces of Attraction and Shapes of Molecules

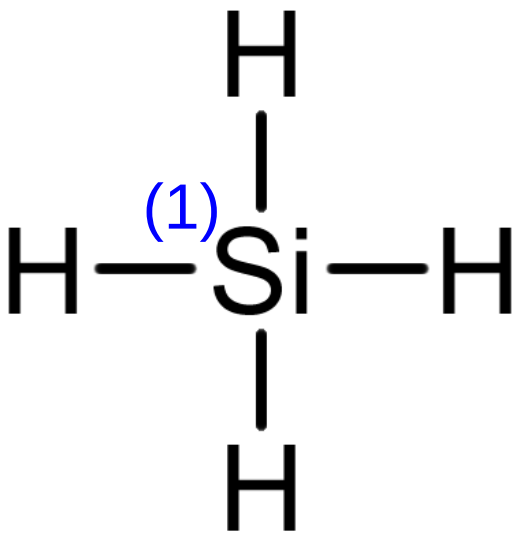
34. Silane



- Number of sigma bonds = 4
- Number of pi bonds = 0
- Number of lone pair electrons = 0

Intermolecular Forces of Attraction and Shapes of Molecules

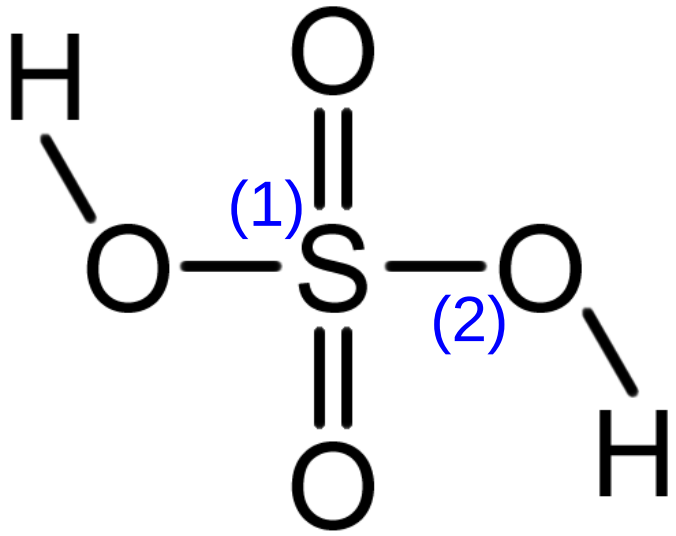
34. Silane



- Shape around silicon (1) = Tetrahedral
- Intermolecular force of attraction = Instantaneous dipole-induced dipole interactions, London dispersion forces

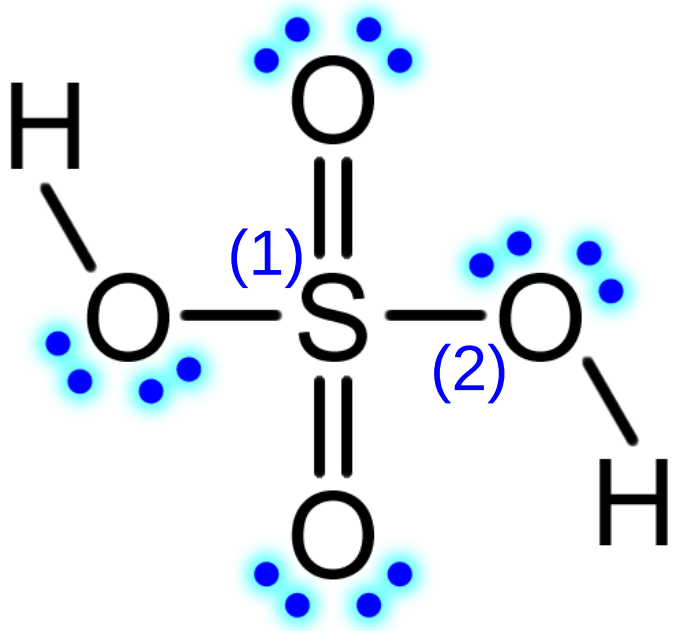
Intermolecular Forces of Attraction and Shapes of Molecules

35. Sulfuric Acid



Intermolecular Forces of Attraction and Shapes of Molecules

35. Sulfuric Acid

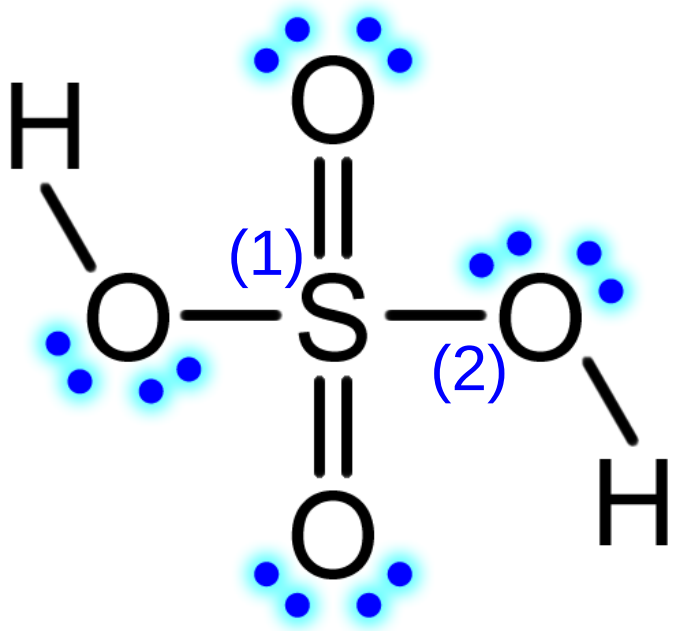


- Lewis Dot Diagram

- Number of sigma bonds = 6
- Number of pi bonds = 2
- Number of lone pair electrons = 8

Intermolecular Forces of Attraction and Shapes of Molecules

35. Sulfuric Acid

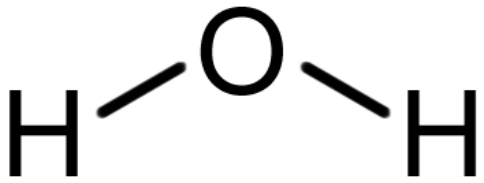


- Lewis Dot Diagram

- Shape around sulfur (1) = Tetrahedral
- Shape around oxygen (2) = Angular
- Intermolecular force of attraction = Hydrogen bonding

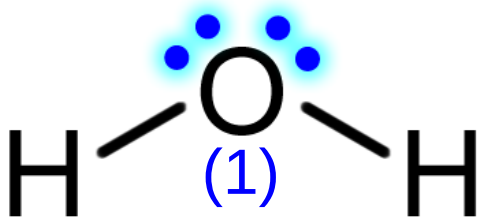
Intermolecular Forces of Attraction and Shapes of Molecules

36. Water



Intermolecular Forces of Attraction and Shapes of Molecules

36. Water



- Lewis Dot Diagram

- Number of sigma bonds = 2
- Number of pi bonds = 0
- Number of lone pair electrons = 2
- Shape around oxygen (1) = Angular
- Intermolecular force of attraction = Hydrogen bonding

Presentation on

Intermolecular Forces of Attraction and Shapes of Molecules

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16th September 2018