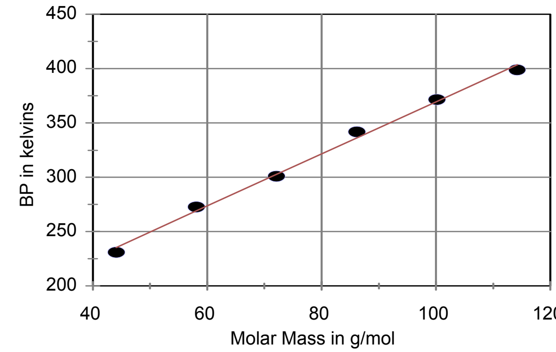
Factors That Effect the Strength of London Forces

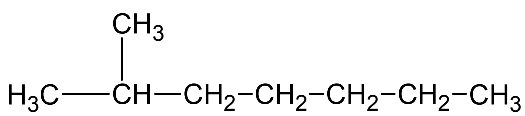
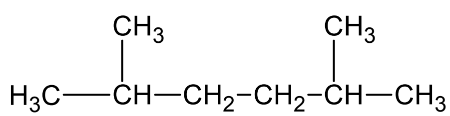
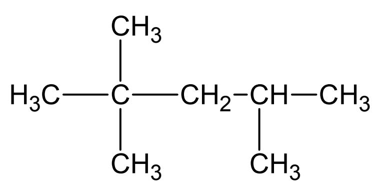
The Effect of Size on the Strength of London Forces

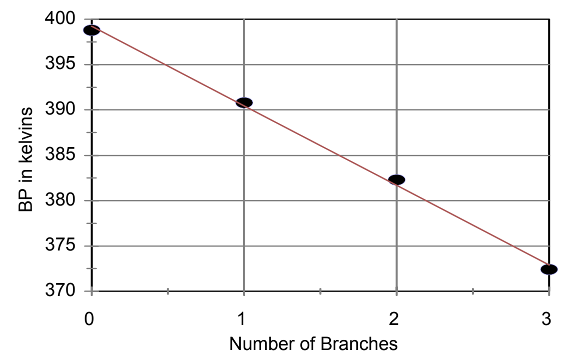
Name	Molar mass	Formula	ΔH_{Vap}	Boiling Pt.
propane	44.096 g/mol	$H_3C-CH_2-CH_3$	16.25 kJ/mol	231.1 K
butane	58.123 g/mol	$H_3C-CH_2-CH_2-CH_3$	22.44 kJ/mol	272.7 K
pentane	72.150 g/mol	$H_3C-CH_2-CH_2-CH_2-CH_3$	26.75 kJ/mol	301.0 K
hexane	86.177 g/mol	$H_3C-CH_2-CH_2-CH_2-CH_2-CH_3$	31.73 kJ/mol	341.9 K
heptane	100.203 g/mol	$H_3C-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$	36.66 kJ/mol	371.6 K
octane	114.230 g/mol	$H_3C-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$	41.53 kJ/mol	398.8 K



Note: The boiling point increases with the number of electrons which generally increase as mass increases. Therefore, the boiling point generally increases with mass as shown in the graph above.

The Effect Shape on the Strength of London Forces Using Isomers

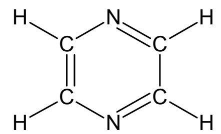
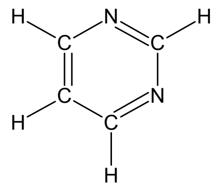
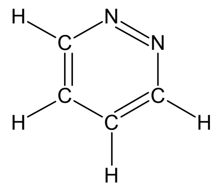
Name of C_8H_{18}	Formula	ΔH_{Vap}	Boiling Pt.
octane	$H_3C-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$	41.53 kJ/mol	398.8 K
2-methyl heptane		39.72 kJ/mol	390.8 K
2,5-dimethyl hexane		37.92 kJ/mol	382.3 K
2,2,4-trimethyl pentane		35.24 kJ/mol	372.4 K



Note: As elongated molecules are more easily polarized than more compact molecules, the elongated molecules have higher boiling points than more compact branched molecules.

Dipole-Dipole Forces as Additional Intermolecular Forces

Comparison of Isomers

Formula	Structure	Molecular Polarity	Boiling Pt.
$C_4H_4N_2$		Non-Polar	388 K
$C_4H_4N_2$		Slightly Polar	397 K
$C_4H_4N_2$		Polar	481 K

Note: For isomers (which must have the same mass), the boiling point of the polar isomers are higher than the boiling point of the non-polar isomer. Also as the polarity increases the strength of the Dipole-Dipole Forces increases and thus the boiling point increases even more.

Comparison of Different Molecules with Approximately the Same Molar Mass

Formula	Molar Mass	Molecular Polarity	Boiling Pt.
N_2	28.0 g/mol	Non-Polar	77 K
CO	28.0 g/mol	Polar	82 K
NO	30.0 g/mol	Polar	121 K
O_2	32.0 g/mol	Non-Polar	90 K

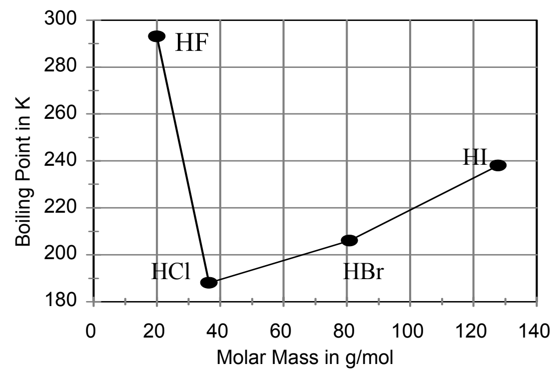
Note: For molecules which have approximately the same molar masses, those which are polar and therefore have Dipole-Dipole Forces in addition to London Forces have higher boiling points.

Note: For most molecules the London Forces make a greater contribution than do Dipole-Dipole Forces to the total IMF.

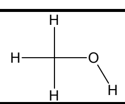
Hydrogen Bonding as an Unusually Strong Dipole-Dipole Force

Comparison of Polar Molecules of Varying Molar Masses with a H-Bonding Molecule

Formula	Molar Mass	Molecular Polarity	Boiling Pt.
HI	127.9 g/mol	Polar	238 K
HBr	80.9 g/mol	Polar	206 K
HCl	36.5 g/mol	Polar	188 K
HF	20.0 g/mol	Polar w/ H-Bonding	293 K



Comparison of Molecules of Similar Molar Masses with a H-Bonding Molecule

Formula	Molar Mass	Molecular Polarity	Boiling Pt.
O_2	32.0 g/mol	Non-Polar	90 K
NO	30.0 g/mol	Polar	121 K
CH_3OH 	30.0 g/mol	Polar w/ H-Bonding	338 K

Note: This data suggests that for molecules of this size, London Forces account for approximately 90 K of the BP, while normal dipole-dipole forces account for approximately 31 K (121 K - 90 K). Notice the unusually high BP of CH_4O. When H-Bonding is present the "dipole-dipole" forces make a greater contribution than London Forces. In this case approximately 248 K. This is why H-Bonding is considered as a separate force than normal Dipole-Dipole forces.