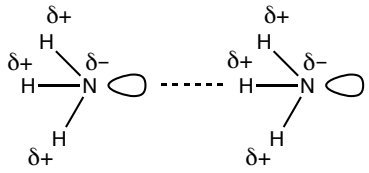
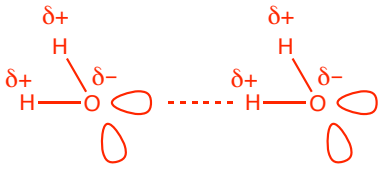
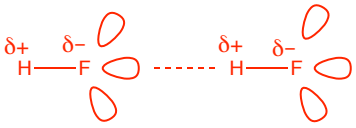
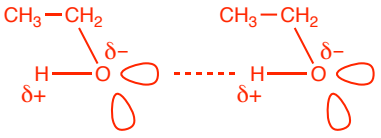
FORCES BETWEEN MOLECULES

NH_3 	H_2O 
HF 	CH_3CH_2OH 

TASK 1 – Boiling points of hydrides of Groups 4, 5, 6 and 7

Why are H_2O, HF and NH_3 so much higher than other hydrides in their groups?	They have hydrogen bonds between their molecules but the other molecules do not. Hydrogen bonds are significantly stronger than other intermolecular forces
Why is the effect greater for H_2O than for HF and NH_3?	Each water molecule is involved in attractions through hydrogen bonds to four other molecules, but HF and NH_3 to only two each
Why do boiling points generally increase down a group?	Molecules have more electrons and so van der Waals' forces between molecules increase
Why are boiling points of Group 4 hydrides lower than hydrides of Groups 5, 6 and 7?	Group 4 hydrides are non-polar and so only have van der Waals' forces between molecules, whereas hydrides of Groups 5, 6 and 7 are polar and so have dipole-dipole attractions between molecules

TASK 2 – Which molecule in each pair has a higher boiling point?

	molecule	van der Waals' (✓)	dipole-dipole (✓)	hydrogen bonds (✓)	which molecule is likely to have higher boiling point?
1) CH_4 & C_4H_{10}	CH_4	✓			C_4H_{10}
	C_4H_{10}	✓			
2) H_2O & H_2S	H_2O	✓		✓	H_2O
	H_2S	✓	✓		
3) CF_4 & CHF_3	CF_4	✓			CHF_3
	CHF_3	✓	✓		
4) $(CH_3)_3N$ & $(CH_3)_2NH$	$(CH_3)_3N$	✓	✓		$(CH_3)_2NH$
	$(CH_3)_2NH$	✓		✓	

TASK 3 – Explain why the molecule in each pair has a higher boiling point

pair	molecule	boiling point	why one boiling point is higher than the other
5)	Cl_2	–34°C	Cl_2 has van der Waals' forces between molecules only Br_2 has van der Waals' forces between molecules only Br_2 higher as greater van der Waals' forces between molecules due to molecule having more electrons
	Br_2	59°C	
6)	CO_2	–78°C	CO_2 has van der Waals' forces between molecules only (molecule is linear and so non-polar) SO_2 has van der Waals' and dipole-dipole forces between molecules (molecule is bent and so polar) SO_2 has dipole-dipole (which CO_2 does not), and has greater van der Waals' forces between molecules due to molecule having more electrons
	SO_2	–10°C	

7)	HBr	–66°C	HBr has van der Waals' and dipole-dipole forces between molecules (molecule is bent and so polar) Br_2 has van der Waals' forces between molecules only Br_2 has van der Waals' forces between molecules only but these must be much stronger than the combination of van der Waals' and dipole-dipole forces between molecules in HBr as Br_2 contains many more electrons
	Br_2	59°C	
8)	CH_3OCH_3	–24°C	CH_3OCH_3 has van der Waals' and dipole-dipole forces between molecules (molecule is bent and so polar) CH_3CH_2OH has van der Waals' forces and hydrogen bonds between molecules CH_3CH_2OH has higher boiling point due to presence of hydrogen bonds which are strongest force between molecules
	CH_3CH_2OH	78°C	
9)	H_2O	100°C	H_2O and HF both have van der Waals' forces and hydrogen bonds between molecules In H_2O, each molecule is involved in hydrogen bonds to four other molecules, but in HF each molecule is only involved in hydrogen bonds to two other molecules
	HF	20°C	