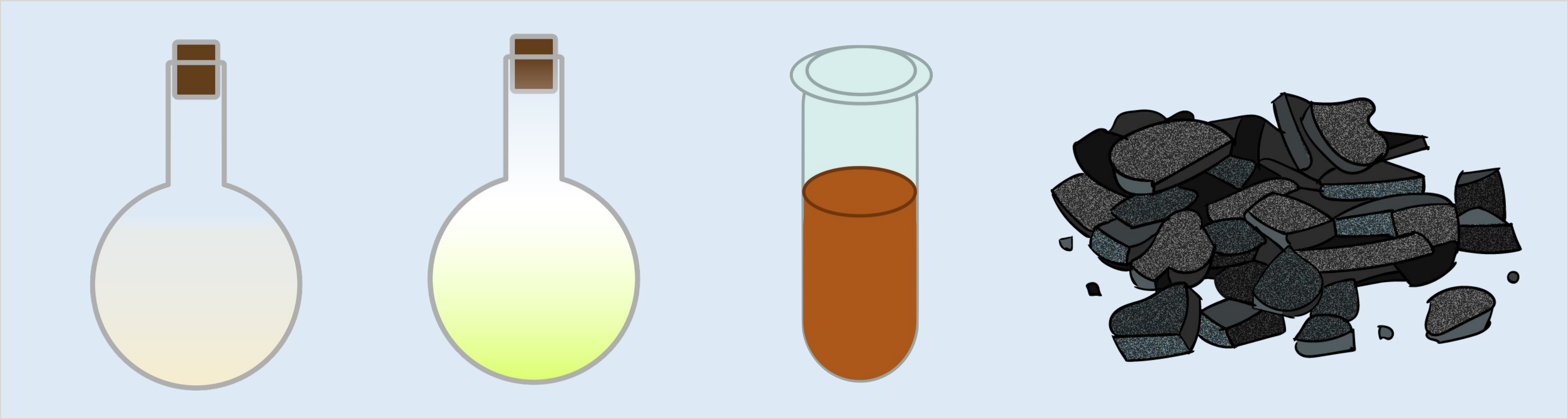
Trends in The Periodic Table-
The Halogens



Material Covered

Edexcel

9.	understand reasons for the trends in melting and boiling temperatures, physical state at room temperature, and electronegativity for Group 7 elements
10.	understand reasons for the trend in reactivity of Group 7 elements down the group
11.	understand the trend in reactivity of Group 7 elements in terms of the redox reactions of Cl_2, Br_2 and I_2 with halide ions in aqueous solution, followed by the addition of an organic solvent
12.	understand, in terms of changes in oxidation number, the following reactions of the halogens: i oxidation reactions with Group 1 and 2 metals ii the disproportionation reaction of chlorine with water and the use of chlorine in water treatment iii the disproportionation reaction of chlorine with cold, dilute aqueous sodium hydroxide to form bleach iv the disproportionation reaction of chlorine with hot alkali v reactions analogous to those specified above
13.	understand the following reactions: i solid Group 1 halides with concentrated sulfuric acid, to illustrate the trend in reducing ability of the hydrogen halides ii precipitation reactions of the aqueous anions Cl^-, Br^- and I^- with aqueous silver nitrate solution, followed by aqueous ammonia solution iii hydrogen halides with ammonia and with water (to produce acids)
14.	be able to make predictions about fluorine and astatine and their compounds, in terms of knowledge of trends in halogen chemistry

AQA

The trends in electronegativity and boiling point of the halogens.

Students should be able to:

- explain the trend in electronegativity
- explain the trend in the boiling point of the elements in terms of their structure and bonding.

The trend in oxidising ability of the halogens down the group, including displacement reactions of halide ions in aqueous solution.

The trend in reducing ability of the halide ions, including the reactions of solid sodium halides with concentrated sulfuric acid.

The use of acidified silver nitrate solution to identify and distinguish between halide ions.

The trend in solubility of the silver halides in ammonia.

Students should be able to explain why:

- silver nitrate solution is used to identify halide ions
- the silver nitrate solution is acidified
- ammonia solution is added.

The reaction of chlorine with water to form chloride ions and chlorate(I) ions.

The reaction of chlorine with water to form chloride ions and oxygen.

Appreciate that society assesses the advantages and disadvantages when deciding if chemicals should be added to water supplies.

The use of chlorine in water treatment.

Appreciate that the benefits to health of water treatment by chlorine outweigh its toxic effects.

The reaction of chlorine with cold, dilute, aqueous NaOH and uses of the solution formed.

Required practical 4

Carry out simple test-tube reactions to identify:

- cations – Group 2, NH_4^+
- anions – Group 7 (halide ions), OH^-, CO_3^{2-}, SO_4^{2-}

OCR

Characteristic physical properties

(a) existence of halogens as diatomic molecules and explanation of the trend in the boiling points of Cl_2, Br_2 and I_2, in terms of induced dipole–dipole interactions (London forces) **(see also 2.2.2 k)**

Redox reactions and reactivity of halogens and their compounds

(b) the outer shell s^2p^5 electron configuration and the gaining of one electron in many redox reactions to form 1– ions

(c) the trend in reactivity of the halogens Cl_2, Br_2 and I_2, illustrated by reaction with other halide ions

(d) explanation of the trend in reactivity shown in **(c)**, from the decreasing ease of forming 1– ions, in terms of attraction, atomic radius and electron shielding

(e) explanation of the term *disproportionation* as oxidation and reduction of the same element, illustrated by:

- **(i)** the reaction of chlorine with water as used in water treatment
- **(ii)** the reaction of chlorine with cold, dilute aqueous sodium hydroxide, as used to form bleach
- **(iii)** reactions analogous to those specified in **(i)** and **(ii)**

(f) the benefits of chlorine use in water treatment (killing bacteria) contrasted with associated risks (e.g. hazards of toxic chlorine gas and possible risks from formation of chlorinated hydrocarbons)

Characteristic reactions of halide ions

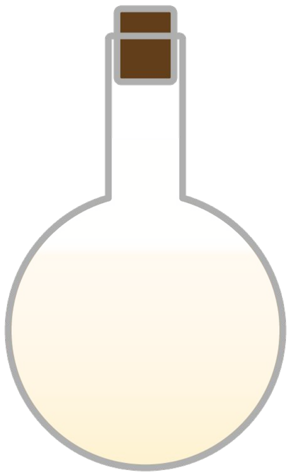
(g) the precipitation reactions, including ionic equations, of the aqueous anions Cl^-, Br^- and I^- with aqueous silver ions, followed by aqueous ammonia, and their use as a test for different halide ions.

The Periodic Table

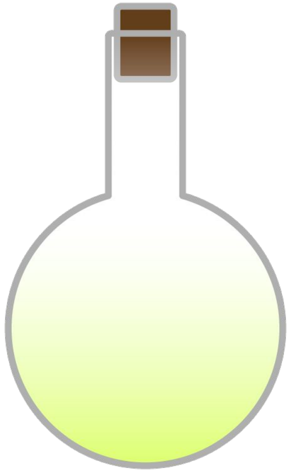
Group 7

1 H Hydrogen																	2 He Helium
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium											13 Al Aluminium	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
55 Cs Cesium	56 Ba Barium	57–71 La–Lu Lanthanides	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon

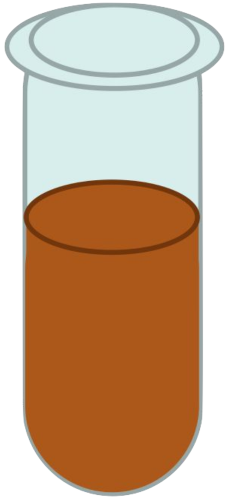
Group 7



F_2



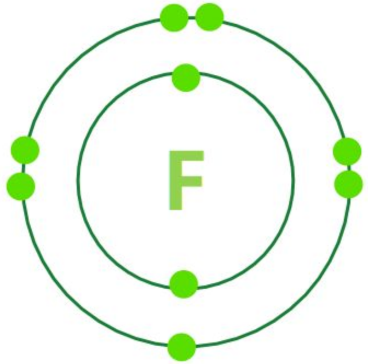
Cl_2

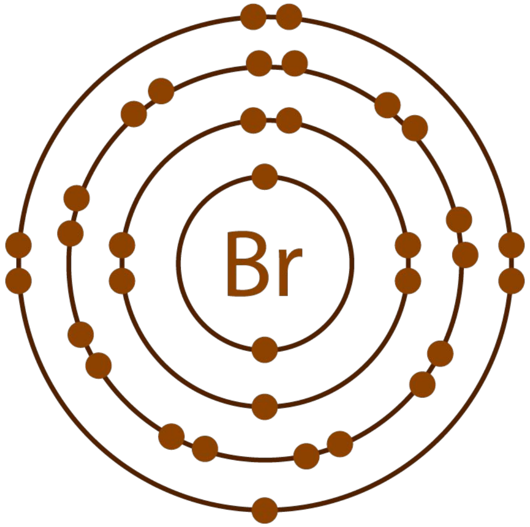


Br_2

I_2

Compounds- Group 7



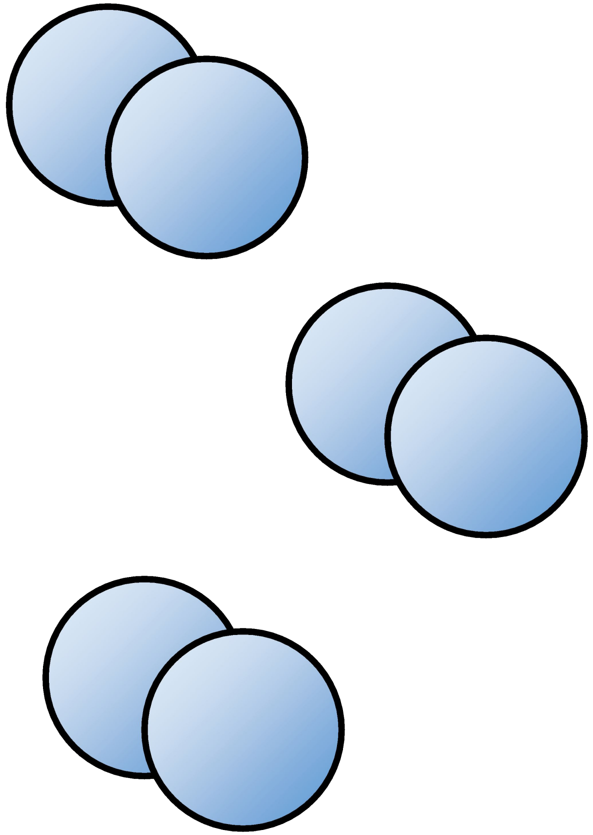


- Halogens need to **gain one electron** to have a full outer shell
- This makes them **highly reactive**
- **Halogens form (-1) anions**

Group 7 Molecules

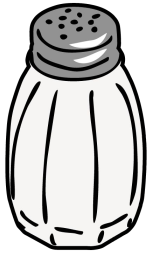
Halogens have **7 electrons** in their outer shell and therefore form **simple covalently-bonded diatomic molecules**

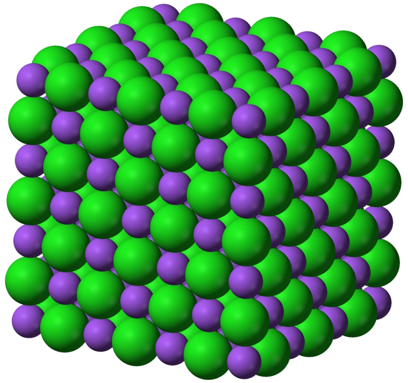
Strong **intra**molecular forces **within** molecules



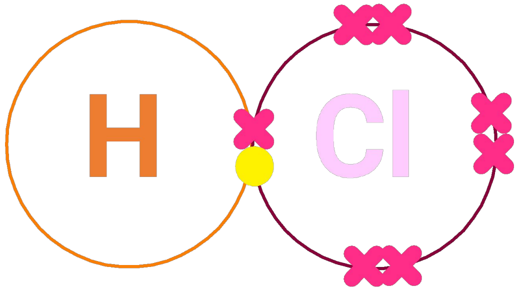
Compounds

A **compound** is a substance that results from bonding between **two or more different chemical elements**





Ionic: NaCl



Polar covalent: HCl

Both soluble - forming ions in aqueous solution

Exemplar Exam Question – Statement

1) Draw dot and cross diagram to show the bonding in:

a) HF (g) **[1 mark]**

b) HI (aq) **[1 mark]**

Command: quick sketch – simple answer needed

Direction: how does bonding differ between gases and aqueous solutions?

Context: dot and cross diagrams

Exemplar Exam Question – Statement

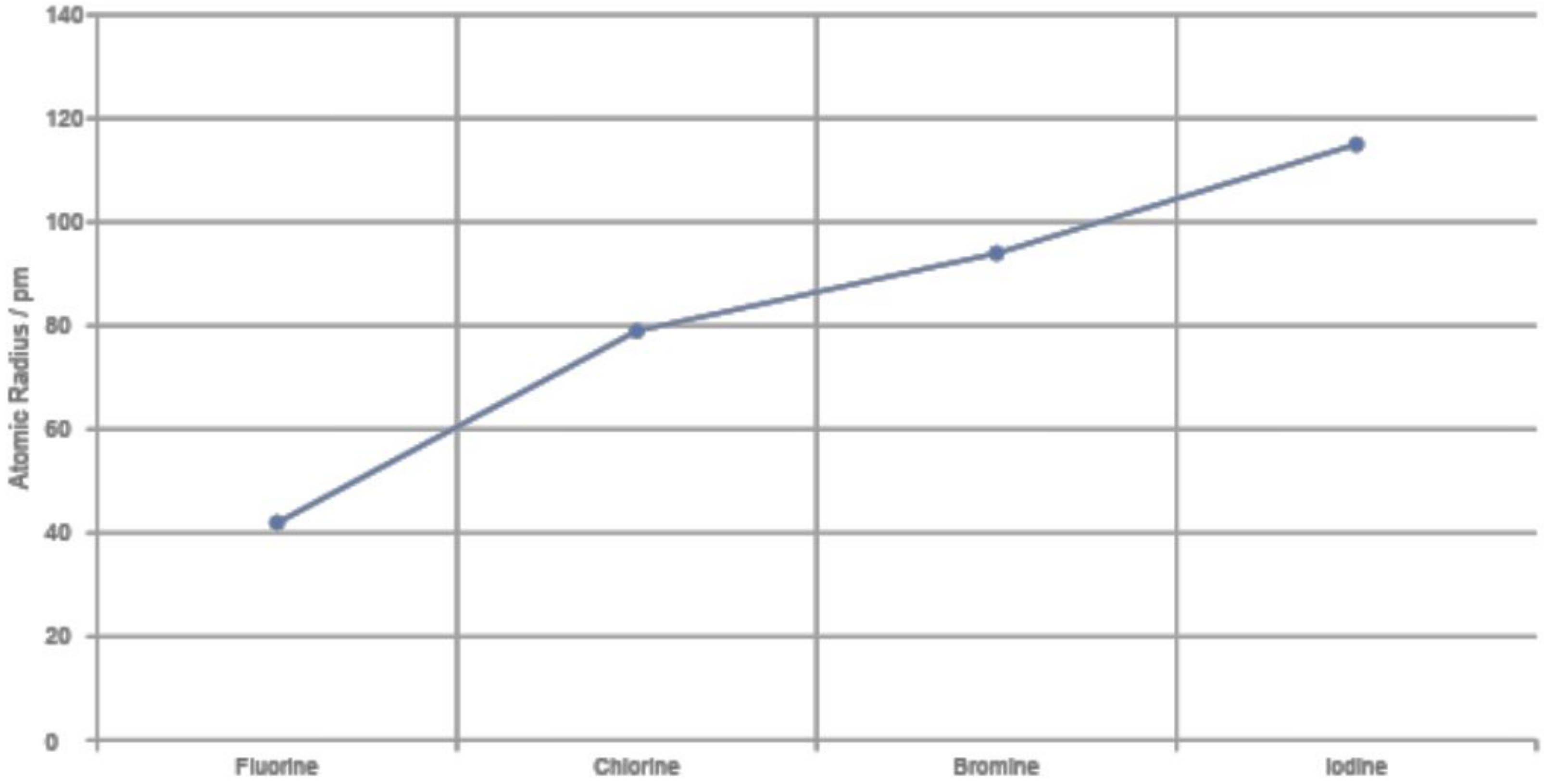
1) Draw dot and cross diagram to show the bonding in:

a) HF (g) **[1 mark]**

b) HI (aq) **[1 mark]**

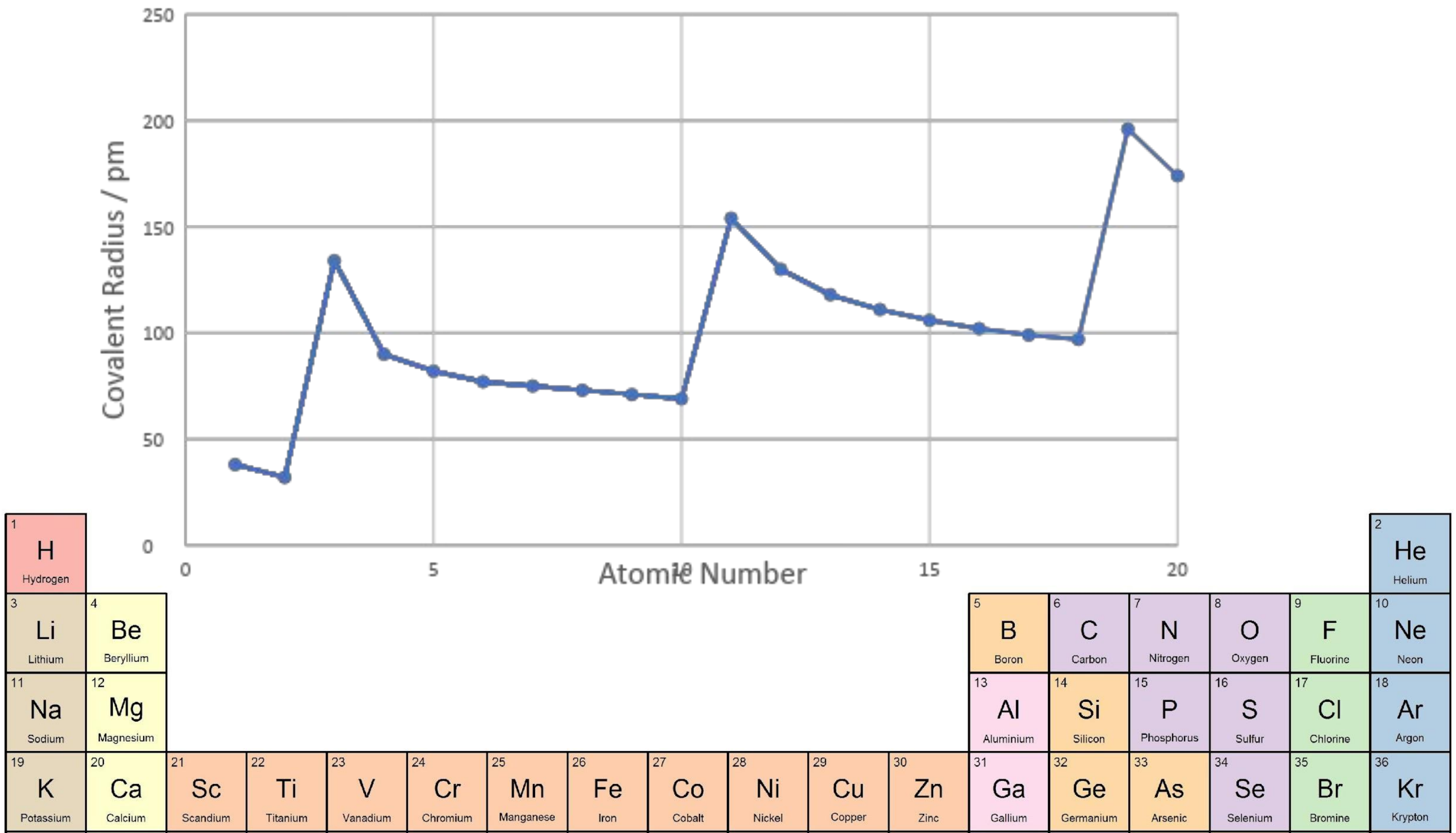
Atomic Size

Moving **down** a **group** of the periodic table, atomic size will always **increase**



Atomic Size

Moving **across** a period, atomic **size decreases**



Exemplar Exam Question – Short Answer

2) State and explain the size difference between F and Na atoms.

[3 marks]

Command: state – simple answer, explain – give reasoning to what we see

Context: atomic size – periodic table

Direction: how and why are F and Na different in size?

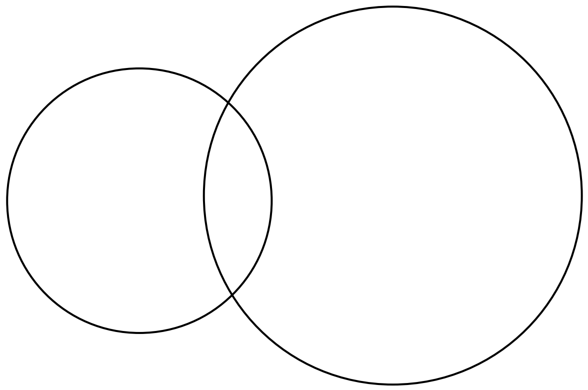
Exemplar Exam Question – Short Answer

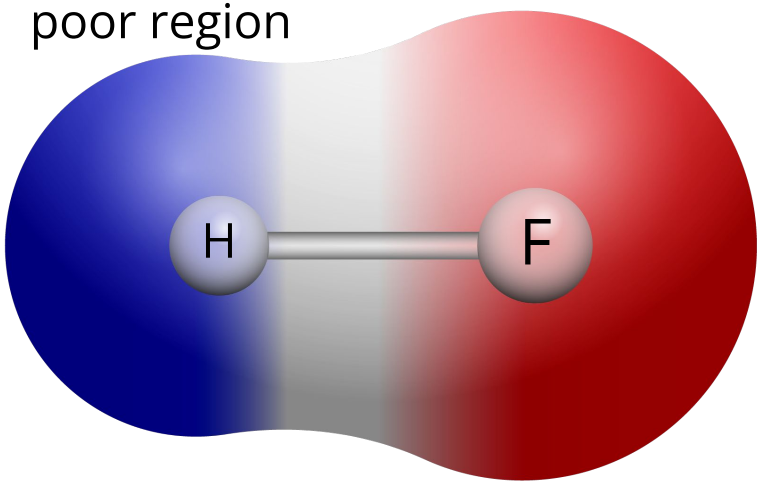
2) State and explain the size difference between F and Na atoms.

[3 marks]

F Na   Increase in number of protons, draws in e-. Increase in number of electron shells results in greater shielding. Overall, the electron repulsion effects are greater in Na atoms, which causes an increase in its atomic size compared to F.

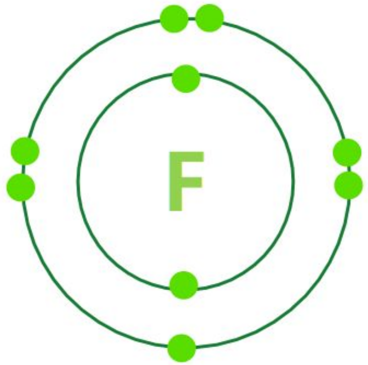
Electronegativity



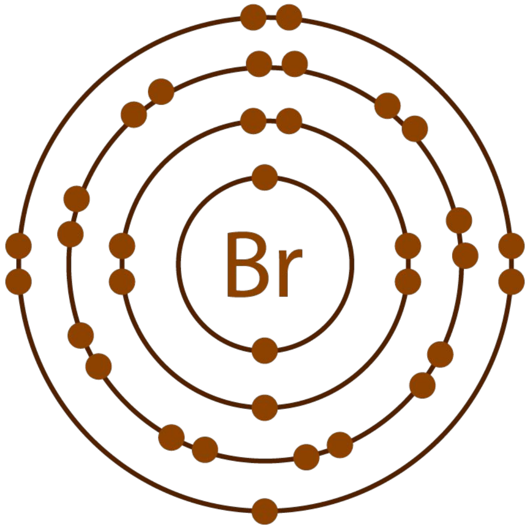


A **covalent bond** is a **strong electrostatic attraction** between a **shared pair of electrons** and the **nuclei** of the **bonded atoms**

Electronegativity



Protons in the nucleus draw all of the **electrons** in the atom towards them –



However, if we add **enough electrons** to **fill a shell**:

- **Bonding electrons** will be further from the nucleus
- More electrons will be **shielding** the nucleus

Electronegativity

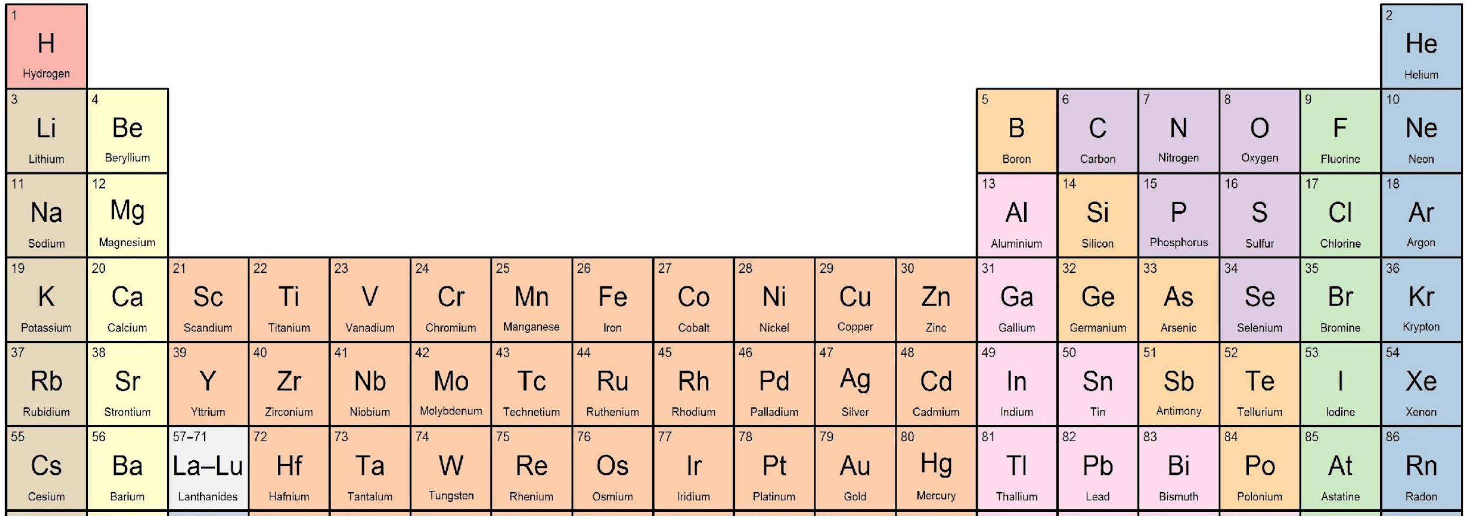
Across a **period:**

> Number of protons increases with electrons being added to the **same shell**

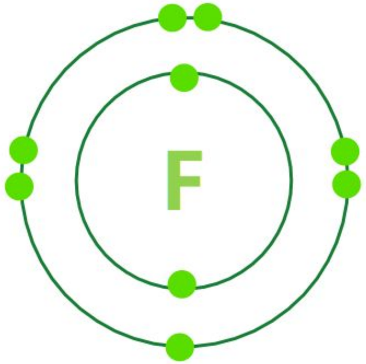
Down a **group:**

>Number of full electron shells **increases**

>Bonding electrons are **further away** from the **nucleus**

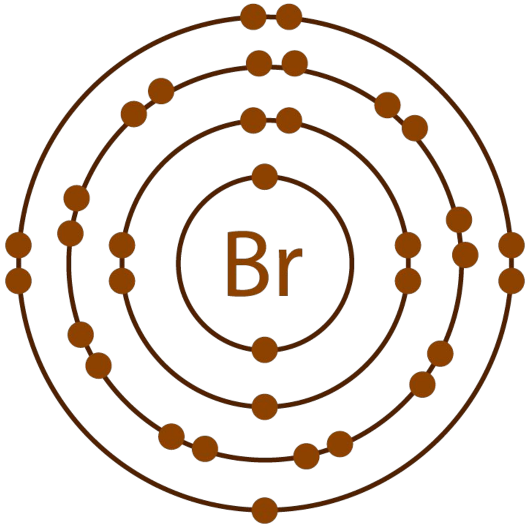


Electronegativity- Group 7



Using these trends we can explain why **reactivity decreases down the group**

Fluorine is the **most reactive** halogen



Exemplar Exam Question – Short Answer

3) By considering the trends in properties of group 7, predict the following for astatine, stating a reason for each:

a) Its physical state at room temperature **[2 marks]**

b) Its atomic size relative to the other halogens **[2 marks]**

c) Its electronegativity relative to the other halogens **[2 marks]**

Direction: how does astatine compare to other group 7 elements

Context: group 7 properties and trends

Command: state your predictions for astatine, giving reasoning

Exemplar Exam Question – Short Answer

3) By considering the trends in properties of group 7, predict the following for astatine, stating a reason for each:

a) Its physical state at room temperature **[2 marks]**

Solid – more electrons, stronger intermolecular forces relative to other halogens.

Exemplar Exam Question – Short Answer

3) By considering the trends in properties of group 7, predict the following for astatine, stating a reason for each:

b) Its atomic size relative to the other halogens **[2 marks]**

Larger – more electron shells.

Exemplar Exam Question – Short Answer

3) By considering the trends in properties of group 7, predict the following for astatine, stating a reason for each:

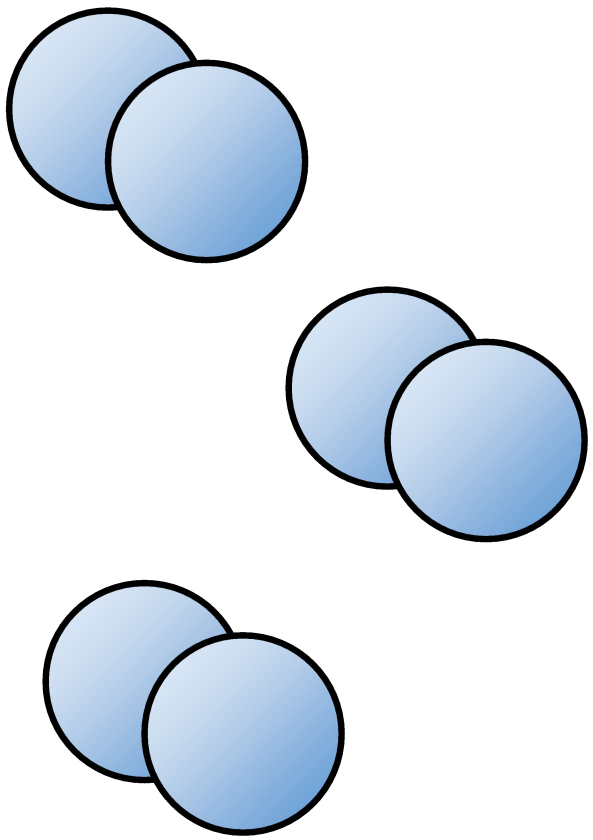
c) Its electronegativity relative to the other halogens **[2 marks]**

Astatine is less electronegative as it has more full electron shells that shield the outer electrons from the nucleus.

Group 7 Molecules

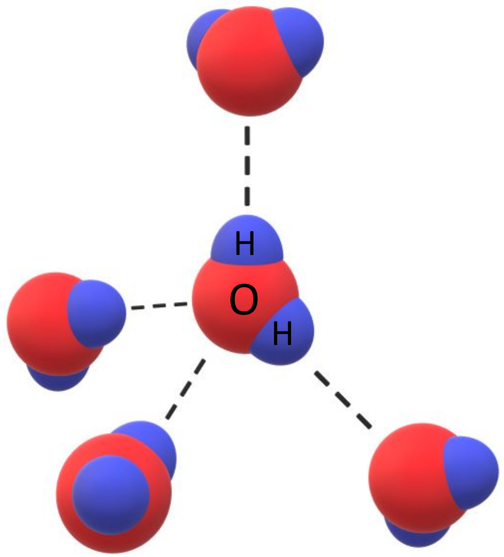
Halogens have **7 electrons** in their outer shell and therefore form **simple covalently-bonded diatomic molecules**

Weak **inter**molecular forces **between** molecules



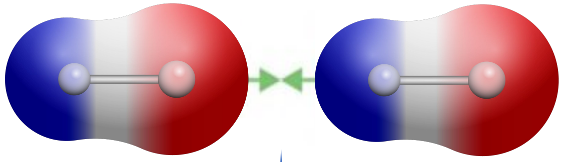
Intermolecular Forces

Hydrogen bonds



Van der Waals

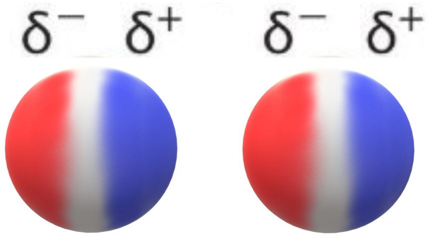
Dipole – dipole interactions



Permanent - Permanent

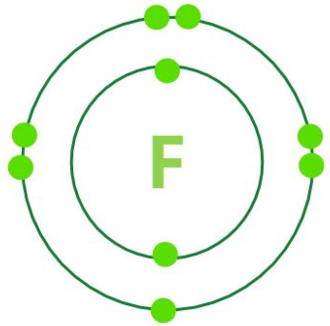
Permanent - Induced

London (dispersion) forces

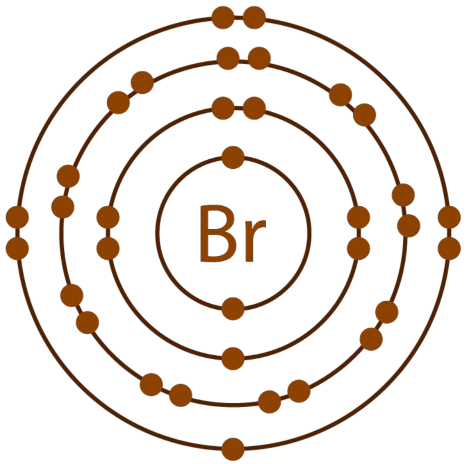


Intermolecular Forces- Group 7

Non-polar molecules



The constant **random movement** of **electrons** leads to the formation of **instantaneous dipoles**



The **force of attraction** is **stronger** the **more electrons** there are

Exemplar Exam Question – Short Answer

4) State and explain the intermolecular forces present between samples of Cl_2, Br_2, I_2 molecules and as a result, their states under standard conditions.

[3 marks]

Command: state – simple answer, explain – give reasoning to what we see

Direction: name all intermolecular forces, gives reasons, give their states

Context: intermolecular forces in group 7

Exemplar Exam Question – Short Answer

4) State and explain the intermolecular forces present between samples of Cl_2, Br_2, I_2 molecules and as a result, their states under standard conditions. **[3 marks]**

London dispersion forces only: instantaneous random dipoles induce and attract opposite dipoles in nearby molecules. Cl_2 gas, Br_2 liquid, I_2 solid – due to an increase in strength of intermolecular forces down the group as the number of e- increases.

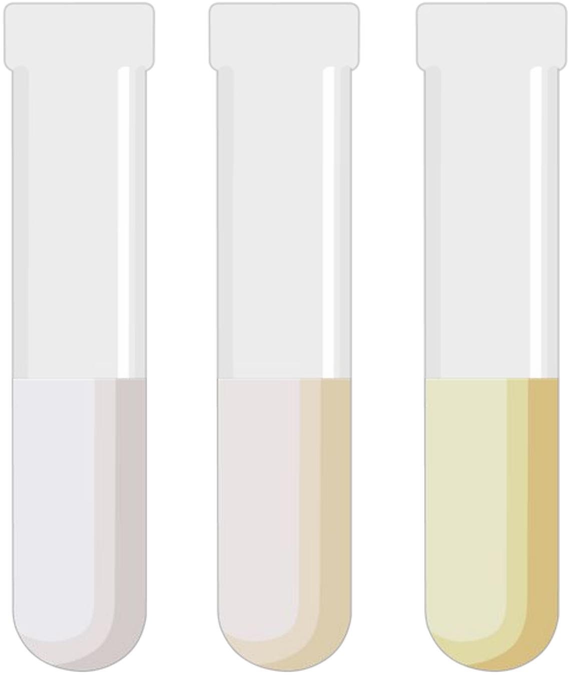
Reactions of the Halogens

Testing for Halide Ions in Aqueous Solution

1) Add **dilute nitric acid**

2) Add a few drops of **aqueous silver nitrate solution**

3) Add **dilute** then **conc. ammonia**



Reactions of the Halogens

Halide Ion	Precipitate with $AgNO_3(aq)$	Appearance of ppt.	Solubility of ppt. in $NH_3(aq)$
Cl^-			
Br^-			
I^-			

Disproportionation reactions

When a reactant is both oxidised and reduced, it is said to be a disproportionation reaction.

Reaction	Cl Oxidation States	Uses
Cl with water		
Cl with Cold Alkali		
Cl with Hot Alkali **Hot not required for OCR**		

Exemplar Exam Question – Short Answer

5) Describe how you could test for the presence of chloride ions in a solution known to contain iodine ions. Give balanced chemical equations for any reactions and describe the appearance of any precipitates formed.

[4 marks]

Command: give a detailed process, state equations and appearances

Direction: give steps for the test, state chemical equations, and state what you would see

Context: halogens and their reactions

Exemplar Exam Question – Short Answer

5) Describe how you could test for the presence of chloride ions in a solution known to contain iodine ions. Give balanced chemical equations for any reactions and describe the appearance of any precipitates formed.

[4 marks]

Add dilute nitric acid, then silver nitrate:

$AgNO_3$ (aq) + NaCl (aq) □ AgCl (s) + $NaNO_3$ (aq) white precipitate

$AgNO_3$ (aq) + NaI (aq) □ AgI (s) + $NaNO_3$ (aq) yellow precipitate

To distinguish, add dil. NH_3 and observe any colour change (as white AgCl precipitate will dissolve leaving only yellow AgI precipitate).

MINI MOCK PAPER

Mini Mock Paper

1)a) Draw a Dot and Cross diagram to show all electrons in F^-.

[1 mark]

1)b) Write the electronic configuration of P, using 1s notation.

[1 mark]

Mini Mock Paper

2) State and explain the trend in electronegativities travelling down the halogen group.

[3 marks]

Mini Mock Paper

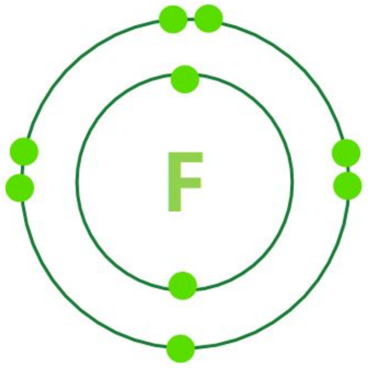
3) Describe the intermolecular forces present in a sample of H_2O. How does this differ from the intermolecular forces present in a sample of CH_4.

[4 marks]

MINI MOCK PAPER ANSWERS

Mini Mock Paper

1)a) Draw a Dot and Cross diagram to show all electrons in F^-.



[1 mark]

1)b) Write the electronic configuration of P, using 1s notation.

[1 mark]

Mini Mock Paper

2) State and explain the trend in electronegativities travelling down the halogens group.

Decreasing electronegativity down the group, as more e- shells are added resulting in greater distance between outer electrons and the nucleus, and greater electron shielding of the nucleus due to more e- . This reduces the ability of the +ve nucleus to attract –ve e- towards it.

[3 marks]

Mini Mock Paper

3) Describe the intermolecular forces present in a sample of H_2O. How does this differ from the intermolecular forces present in a sample of CH_4.

[4 marks]

H_2O: hydrogen bonding – there is a large difference in electronegativity between O and H atoms so the partially positively charged H is attracted to the lone pairs on the partially negatively charged O; dipole-dipole – H_2O is polar so has a permanent dipole and can induce dipoles; London dispersion forces as electrons are involved.

CH_4: London dispersion forces only – CH_4 is non-polar because the electronegativities of C (2.55) and H (2.20) are so similar, so no dipole-dipole or hydrogen bonding present.