

11.1 GROUP 17

Physical properties

Learning outcomes

Candidates should be able to:

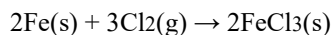
- 1 describe the colours and the trend in the volatility of chlorine, bromine and iodine
- 2 describe and explain the trend in the bond strength of the halogen molecules
- 3 interpret the volatility of the elements in terms of instantaneous dipole–induced dipole forces

Initial assessment

1. Write down the electronic configuration of a bromine atom.
2. The oxidation number of chlorine can vary. Give its oxidation number in the following compounds:



3. Explain which element is oxidised and which is reduced in this reaction:



4. Draw a dot-and-cross diagram to show the covalent bonding in a chlorine molecule, Cl_2 . Only include outer shell electrons.
5. Discuss with a partner what we mean by ‘bond energy’. Compare your answer with another pair of learners and write an agreed-upon definition of the term *bond energy*.
6. State the unit in which bond energies are expressed.

Physical properties

The following table shows some of the physical properties of the halogens.

Group 17 element	Atomic radius /nm	Melting point /°C	Boiling point /°C	Colour
fluorine (F_2)	0.072	-220	-188	pale yellow
chlorine (Cl_2)	0.099	-101	-35	green/yellow
bromine (Br_2)	0.114	-7	59	orange/brown
iodine (I_2)	0.133	114	184	grey/black solid, purple vapour

The melting points and boiling points of the halogens **increase** going down the group. The boiling point data gives us an idea of the volatility of the halogens, i.e., the ease with which they evaporate. All the values are relatively low because they have simple molecular structures.

Volatility: the ease with which a substance evaporates. A volatile substance will evaporate at a low temperature.

There are only weak van der Waals forces between their diatomic molecules, caused by instantaneous dipole-induced dipole forces. These forces increase as the number of electrons in the molecules increases with increasing atomic number. The greater the number of electrons, the greater the opportunities for instantaneous dipoles arising within molecules, and induced dipoles to be produced on neighbouring molecules. The larger the molecules, the stronger the van der Waals forces between molecules. This makes iodine the least volatile and fluorine the most volatile of the halogens you are learning about.

You can also see that the colours of the halogens get darker going down the group.



Bond strength

Decreases down the group because the bonds are weaker. The X-X bond strength depends on the degree of overlap of the np_x valency orbitals on adjacent halogen atoms; this decreases down the group because the orbitals are larger and more diffuse, so a smaller proportion of each of them overlaps. There is also repulsion between the inner-shell electrons on adjacent atoms.

Bond length

Increases down the group.

Due to the increasing size of the atoms.

1. Describe the colours of the Group 17 elements, chlorine to iodine, at room temperature.

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2. The Group 17 elements, chlorine, bromine and iodine, are non-metals that show trends in their physical and chemical properties. [1]

Describe the trend in the colour of the Group 17 elements down the group. [1]

3. The elements of Group 17 are called halogens.

Complete the following table.

[1]

Halogen	colour at 293 K
Chlorine	
Bromine	

Iodine	
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4. State the trend in volatility of the halogens chlorine, bromine and iodine. Explain your answer. [3]

5. The halogens chlorine, bromine and iodine are all volatile elements.
State and explain the trend in volatility down Group 17. [3]
6. The elements in Group 17 are known as the halogens.
Between the molecules of Group 17 elements van der Waals' forces exist.
(i) State the trend in the relative strength of van der Waals' forces down Group 17. [1]

(ii) State the physical state of each of the halogens under room conditions.

chlorine

bromine

iodine

[1]

7. Sulfides are compounds that contain sulfur but not oxygen.
Carbon disulfide, CS₂, is a volatile liquid at room temperature and pressure.
State the meaning of volatile. [1]

1. The table shows bond energies for some diatomic molecules. Deuterium, D, is an isotope of hydrogen.

Energy, / kJ mol ⁻¹	bond
158	F–F
242	Cl–Cl
193	Br–Br
151	I–I
436	H–H
442	D–D

Which statements are correct?

1. Diatomic molecules have exact values for their bond energies, which are always positive.
2. The trend in Group 7 bond energies can be explained by the variation in instantaneous dipole–induced dipole (id–id) forces.
3. A value for the enthalpy change for the reaction between deuterium and chlorine can be calculated using these data alone.

A 1 only

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

2. Which row shows the expected properties of the element astatine when compared to the properties of the element iodine?

	Electronegativity of astatine compared to iodine	Volatility of astatine compared to iodine
A	less electronegative	higher
B	more electronegative	higher

C	less electronegative	lower
D	more electronegative	lower

3. Chlorine and bromine have different volatilities.
Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	intermolecular forces are greater in bromine than they are in chlorine
B	bromine	intermolecular forces are greater in chlorine than they are in bromine
C	chlorine	intermolecular forces are greater in bromine than they are in chlorine
D	chlorine	intermolecular forces are greater in chlorine than they are in bromine

4. In this question, Q represents an atom of chlorine, bromine or iodine.
Which explanation for the variation in volatility down Group 17 is correct?

- A** Instantaneous dipole–induced dipole forces between molecules become stronger.
B Permanent dipole–permanent dipole forces between molecules become stronger.
C The bond energy of the Q_2 molecules decreases.
D The first ionisation energy $Q(g) \rightarrow Q^+(g) + e^-$ decreases.

5. Iodine has a higher melting point than chlorine.
What is the reason for this?

- A** Iodine has stronger covalent bonds than chlorine.
B Iodine molecules have stronger permanent dipoles than chlorine molecules.
C Iodine is more volatile than chlorine.
D Iodine has stronger instantaneous dipole–induced dipole forces than chlorine.

6. Which property explains the trend in volatility of the elements going down Group 17?

- A** decreasing covalent bond strength
B decreasing van der Waals' forces
C increasing covalent bond strength
D increasing van der Waals' forces

7. X, Y and Z are three elements in Group 17.
 X_2 has weaker covalent bonds than Y_2 .
 X_2 has stronger instantaneous dipole–induced dipole forces between its molecules than Z_2 .
 Y_2 is a stronger oxidising agent than Z_2 .
What could be X, Y and Z?

	X	Y	Z
A	Br	Cl	I
B	Cl	Br	I
C	I	Br	Cl
D	I	Cl	Br

8. In this question, Q is used to represent a halogen atom.
Magnesium and calcium each form a compound with chlorine and a compound with bromine.
One of these compounds contains:
- the element in Group 2 with the higher first ionisation energy and
 - the element in Group 17 with the higher Q–Q bond energy.
- What is the formula of this compound?

A MgCl_2

B MgBr_2

C CaCl_2

D CaBr_2

*****This is not a complete note. It is just to guide you. It is recommended to study prescribed textbooks along with this material. *****