

**Group 17 – 2016**

1. 9701/22/M/J/16/No.2

The elements in Group 17, the halogens, and their compounds, show many similarities and trends in their properties. Some data are given for the elements fluorine to iodine.

element	bond energy /kJ mol <sup>-1</sup>	standard enthalpy change of atomisation, $\Delta H_{at}^{\circ}$ /kJ mol <sup>-1</sup>	boiling point of element /K	boiling point of hydrogen halide /K
fluorine, F–F	158	79	85	293
chlorine, Cl–Cl	242	121	238	188
bromine, Br–Br	193	112	332	206
iodine, I–I	151	107	457	238

(a) (i) Explain the meaning of the term *standard enthalpy change of atomisation*.

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 .....  
 ..... [3]

(ii) For fluorine and chlorine, the enthalpy changes of atomisation are half the value of the bond energies.

For bromine and iodine, the enthalpy changes of atomisation are much more than half the value of the bond energies.

Suggest a reason for this difference.

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 .....  
 ..... [1]

(iii) The standard enthalpy of formation of iodine monochloride, ICl, is  $-24.0 \text{ kJ mol}^{-1}$ .

Use this information and the bond energies of iodine and chlorine to calculate the I–Cl bond energy.

I–Cl bond energy = ..... kJ mol<sup>-1</sup> [2]

(b) (i) Explain the trend in the boiling points of the hydrogen halides, HCl, HBr and HI.

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.....  
..... [2]

(ii) Suggest why the hydrogen halide HF does not follow the trend in boiling points shown by HCl, HBr and HI.

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..... [2]

(c) In an experiment, two of the halogens are represented as  $P_2$  and  $Q_2$ .

$P_2$  combines with hydrogen on heating to form  $HP$ , which can be easily broken down into its elements. A solution of  $HP$  in water reacts with aqueous silver ions to form a yellow precipitate that is insoluble in dilute aqueous ammonia.

$Q_2$  combines explosively with hydrogen in sunlight to form  $HQ$ , which is stable to heat. A solution of  $HQ$  in water reacts with aqueous silver ions to form a white precipitate that is soluble in dilute aqueous ammonia.

(i) Identify the halogens  $P_2$  and  $Q_2$ .

$P_2$  = .....  $Q_2$  = ..... [1]

(ii)  $HP$  readily decomposes into its elements when heated but  $HQ$  is stable to heat. Explain this with reference to bond energies.

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..... [2]

(iii) Write an equation for the thermal decomposition of  $HP$ .

..... [1]

(iv) Write ionic equations, including state symbols, for

1. the formation of the white precipitate on addition of aqueous silver ions to aqueous  $\text{H}_2\text{Q}$ ,

.....

2. the subsequent dissolving of this precipitate in dilute aqueous ammonia.

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[2]

(d) Chlorine reacts directly with many elements to form chlorides. Three such compounds are  $\text{MgCl}_2$ ,  $\text{AlCl}_3$  and  $\text{SiCl}_4$ .

- (i) State and explain the pattern shown by the formulae of these three chlorides.

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..... [2]

- (ii) Write equations to show the behaviour of each of these chlorides when added to water.

$\text{MgCl}_2$  .....

$\text{AlCl}_3$  .....

$\text{SiCl}_4$  .....

[3]

[Total: 21]