Chapter 4: Chemical bonding

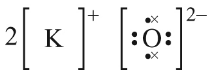
Homework marking scheme

1 **a** $K(g) \rightarrow K^+(g) + e^-$ [1]

b Each element in the group has to lose one electron when it reacts.
The more easily it loses this electron, the more reactive it is. [1]
As the group is descended the outer electron is further from the nucleus and the atomic radius increases. [1]
Also the number of inner electron shells increases, thus increasing the shielding of the outer electron from the positively charged nucleus. [1]
All these factors result in the first electron ionisation energy decreasing and the reactivity of the element also increasing. [1]

c **i** $4K(s) + O_2(g) \rightarrow 2K_2O(s)$ (unless they are specifically asked for, the state symbols are not essential in such an equation) [1]

ii



Two potassium ions with no electrons in the outer shell. [1]
Oxide ion with four pairs of electrons round it and correctly labelled with a 2− charge. [1]
Two of the electrons on the oxide ion being of a different type to the other six, showing they were from the potassium atoms. [1]

iii number of moles of potassium nitrate = $\frac{2}{10}$ × number of moles of potassium [1]

number of moles of potassium = $\frac{7.82}{39.1} = 0.2$ mol [1]

number of moles of potassium nitrate = $\frac{2}{10} \times 0.2 = 0.04$ mol [1]

mass of potassium nitrate = $101.1 \times 0.04 = 4.04$ g [2]
Note: you will lose the final mark if you express the answer to more than three significant figures.

iv number of moles of potassium oxide = $\frac{6}{10}$ × the number of moles of potassium [1]

$= \frac{6}{10} \times 0.2 = 0.12$ mol [1]

mass of $K_2O = 94.2 \times 0.12 = 11.3$ g
1 mark is for the correct M_r of potassium oxide [2]

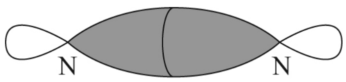
v In the solid state the potassium ions and oxide ions are not free to move and therefore cannot carry the current. [1]
In the liquid state the ions are free to move and can carry the current. [1]

2 a i

three pairs of electrons between the two nitrogen atoms [1]

the two lone pairs, one pair shown as dots and the other as crosses [1]

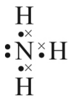
ii



[1]

iii pi or π [1]

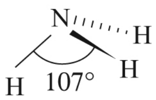
b i



three dot-and-cross bonds [1]

the lone pair on the nitrogen atom. [1]

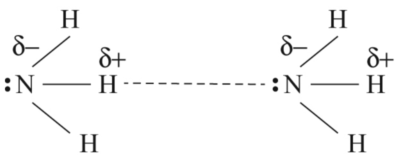
ii



three-dimensional representation of the molecule [1]

the correct bond angle [1]

iii

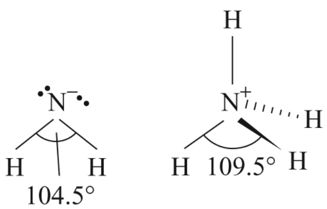


correct dipoles [1]

lone-pair electrons on the nitrogen with the hydrogen bond [1]

hydrogen bond as a dashed line [1]

iv



For each ion, 1 mark is for a three-dimensional representation where appropriate and 1 mark is for the correct bond angle. The bond angle of 104.5° for the amide ion is because of the two lone pairs on the nitrogen with a stronger repulsion of the bonds, thus decreasing the bond angle. [4]

c i

Substance	**Electrical conductivity**	
	as solid	**as liquid**
Sodium	good	good
Sodium amide	poor	good

[4]

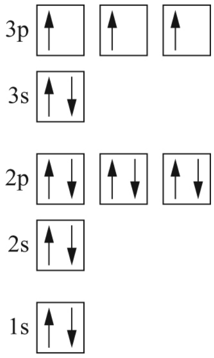
ii The sodium owes its electrical conductivity to the movement of electrons; these can move freely in both the solid and the liquid state hence carrying the current. [1]

In sodium amide the particles carrying the current are ions; these cannot move freely in the solid state but can in the liquid state, hence the differences in electrical conductivity. [1]

iii The ions are alternate [1]
so that the corners are the large spheres [1]
whilst the others have the small spheres. [1]

iv The ion has lost the outer single electron, and overall has one more proton in the nucleus than electrons in the orbitals, so the electron cloud is drawn closer to the nucleus than in the atom. [3]

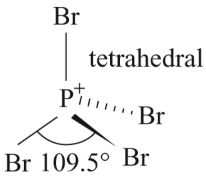
3 a i



correct number of boxes in each energy level [1]
correct labelling of the energy levels [1]
three unpaired electrons in the 3p energy level with spins in the same direction [1]

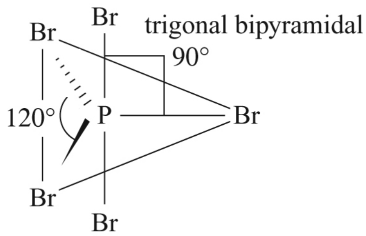
ii ^{32}P has 15 electrons, 15 protons and 17 neutrons
^{31}P has 15 electrons, 15 protons and 16 neutrons [1]
the similarity is the number of electrons and protons; the difference is the number of neutrons [1]

b i



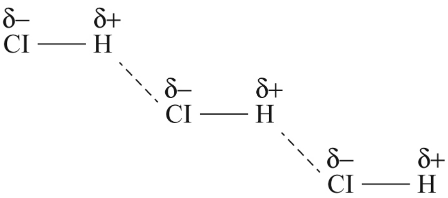
correct three-dimensional representation of the ion [1]
correct bond angle [1]
correctly labelling the shape, i.e. tetrahedral [1]

ii



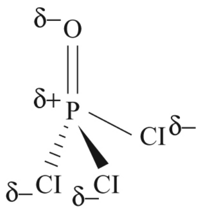
drawing the molecule showing a three-dimensional representation [1]
two correct bond angles [1]
naming the shape [1]

c i



at least two molecules of HCl shown, with correct dipoles on each molecule [1]
dipole–dipole interactions shown as dashed lines [1]

ii



The bond angles are 109.5° because it is a tetrahedral molecule. [1]

iii phosphorus as electron deficient, shown as δ+ [1]

chlorine atoms and the oxygen atom shown as δ− [1]

iv The melting point of phosphorus oxychloride is 1 °C and its boiling point is 105 °C [1]

at 20 °C it has melted but not boiled [1]

and therefore it is a liquid at room temperature [1]