Covalent Bonding & Shapes of Molecules

Question Paper 4

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Chemical Bonding
Sub-Topic	Covalent Bonding & Shapes of Molecules
Paper Type	Theory
Booklet	Question Paper 4

Time Allowed: **66 minutes**

Score: **/55**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** Chlorine exists naturally as a mixture of two isotopes, ^{35}Cl and ^{37}Cl, in the abundance ratio of 3 : 1.

The mass spectrum of chlorine consists of five peaks.

(i) Suggest the mass numbers for these five peaks and the identities of the species responsible.

mass number	formula of species

(ii) Predict the ratios of the abundances of the three species with the highest mass numbers.

ratio of abundances = ...
[4]

(b) Strontium chloride, $SrCl_2$, can be used to produce a red colour in fireworks.

(i) Draw the 'dot-and-cross' diagram for strontium chloride. Show outer shell electrons only.

(ii) Use the following data, together with relevant data from the *Data Booklet*, to calculate a value for the lattice energy of strontium chloride. You may find it helpful to construct a Born-Haber cycle.

electron affinity per mole of chlorine atoms	–349 kJ mol^{-1}
standard enthalpy of atomisation of Sr(s)	+164 kJ mol^{-1}
standard enthalpy of formation of SrCl_2(s)	–830 kJ mol^{-1}

lattice energy = ... kJ mol^{-1}
[5]

(c) Strontium nitrate, $Sr(NO_3)_2$, can also be used to produce a red colour in fireworks.

(i) Strontium nitrate can easily be prepared from strontium carbonate, $SrCO_3$.

Suggest an equation for this preparation of strontium nitrate.

.....

(ii) Write an equation for the reaction that occurs when strontium nitrate is heated.

.....
[2]

(d) Describe and explain the trend in the thermal stabilities of the nitrates of the Group II elements.

.....

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.....

.....

..... [3]

[Total: 14]

2 Valence Shell Electron Pair Repulsion theory (VSEPR) is a model of electron-pair repulsion (including lone pairs) that can be used to deduce the shapes of, and bond angles in, simple molecules.

(a) Complete the table below by using simple hydrogen-containing compounds. One example has been included.

number of bond pairs	number of lone pairs	shape of molecule	formula of a molecule with this shape
3	0	trigonal planar	BH_3
4	0		
3	1		
2	2		

[3]

(b) Tellurium, Te, proton number 52, is used in photovoltaic cells.

When fluorine gas is passed over tellurium at 150 °C, the colourless gas TeF_6 is formed.

(i) Draw a 'dot-and-cross' diagram of the TeF_6 molecule, showing outer electrons only.

(ii) What will be the shape of the TeF_6 molecule?

.....

(iii) What is the F–Te–F bond angle in TeF_6?

.....

[3]

[Total: 6]

3 **(a)** Gaseous ammonia reacts with gaseous hydrogen chloride to form solid ammonium chloride.

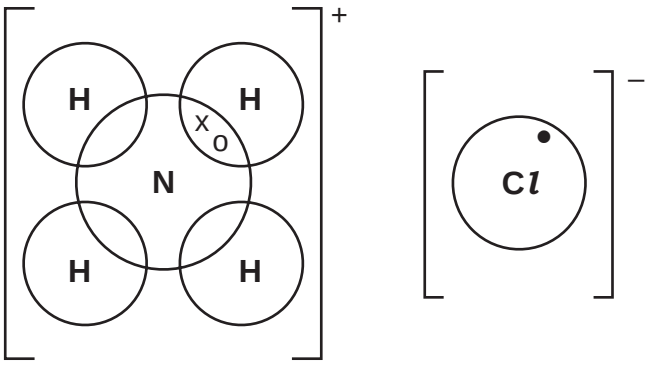
$$NH_3 + HCl \rightarrow NH_4Cl$$

The bonding in ammonium chloride includes ionic, covalent and co-ordinate (dative covalent) bonds.

Complete the following 'dot-and-cross' diagram of the bonding in ammonium chloride. For **each** of the six atoms show **all** the electrons in its outer shell. Three electrons have already been included.

Use the following code for your electrons.

- ● electrons from chlorine
- x electrons from hydrogen
- o electrons from nitrogen



[3]

(b) When a sample of dry ammonia is needed in the laboratory, the gas is passed through a tower containing lumps of solid calcium oxide, CaO.

(i) Suggest why the usual drying agent for gases, concentrated H_2SO_4, is **not** used for ammonia.

.....

(ii) Write an equation for the reaction between CaO and H_2O.

.....

(iii) Suggest why CaO rather than MgO is used to dry ammonia.

.....

[3]

(c) **(i)** Write an equation showing the thermal decomposition of calcium nitrate, $Ca(NO_3)_2$.

.....

(ii) State and explain how the thermal stabilities of the nitrates vary down Group II.

.....

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.....

.....

[4]

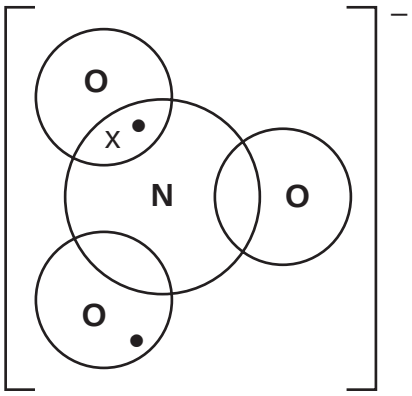
[Total: 10]

4 **(a)** The nitrate ion, NO_3^-, contains a dative covalent bond.

Complete the following 'dot-and-cross' diagram of the bonding in the nitrate ion. For **each** of the four atoms show **all** the electrons in its outer shell. Three electrons have already been included.

Use the following code for your electrons.

- ● electrons from oxygen
- x electrons from nitrogen
- □ added electron(s) responsible for the overall negative charge



[3]

(b) Write an equation showing the action of heat on magnesium nitrate, $Mg(NO_3)_2$.

.....

(ii) Describe and explain the trend that is observed in the thermal stabilities of the Group II nitrates.

.....

.....

.....

.....

[4]

(c) When concentrated nitric acid, HNO_3, is added to copper turnings, a brown gas is evolved. Use data from the *Data Booklet* to construct an ionic equation for this reaction.

.....

.....

[2]

[Total: 9]

5 The elements of the third period of the Periodic Table, sodium to sulfur, all form chlorides by direct combination.

(a) (i) Sulfur forms a number of chlorides which are liquid at room temperature.
Which other element of the third period forms a chloride which is liquid at room temperature?

.....

(ii) Name **one** element of the third period which burns in chlorine with a coloured flame.

.....

(iii) Aluminium chloride may be produced by passing a stream of chlorine over heated aluminium powder in a long hard-glass tube.
State **two** observations you could make during this reaction.

..... and .....

(iv) Write a balanced equation, with state symbols, for this reaction of aluminium with chlorine.

.....

(v) No chloride of argon has ever been produced.
Suggest a reason for this.

.....

.....

[7]

(b) When chlorides of the elements of the third period are added to water, some simply dissolve while others can be seen to react with the water.

(i) Complete the table below, stating how the chlorides of Na, A*l*, and Si behave when mixed with water. In the first column use only the terms 'dissolve' or 'react'.

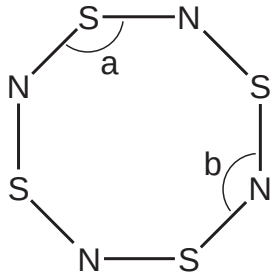
element	Does the chloride dissolve or react?	approximate pH of the resulting solution
Na		
A*l*		
Si		

(ii) What *type of reaction* takes place between a chloride and water?

.....

[7]

(c) Sulfur forms the compound S_4N_4 with nitrogen. The structure of S_4N_4 is shown below. Assume all bonds shown are single bonds.



(i) Determine the number of lone pairs of electrons around a nitrogen atom and a sulfur atom in S_4N_4.

nitrogen atom .....

sulfur atom .....

(ii) Which bond angle, a or b, in the S_4N_4 molecule will be smaller? Explain your answer.

.....

.....

[2]

[Total: 16]