Q1.

Which pair of reagents reacts to form a tetrahedral complex?

A $CoCl_2(aq)$ and concentrated $NH_3(aq)$ ⬭

B $CuSO_4(aq)$ and concentrated $NH_3(aq)$ ⬭

C $CuSO_4(aq)$ and sodium ethanedioate(aq) ⬭

D $FeCl_3(aq)$ and concentrated HCl(aq) ⬭

(Total 1 mark)

Q2.

Which has a bond angle of 109.5°?

A C (diamond) ⬭

B C (graphite) ⬭

C NH_2^- ⬭

D NH_3 ⬭

(Total 1 mark)

Q3.

Which species is **not** pyramidal in shape?

A PF_3 ⬭

B H_3O^+ ⬭

C CH_3^- ⬭

D BF_3 ⬭

(Total 1 mark)

Q4.

Which species has a square planar shape?

A NH_4^+ ⬭

B SF_4 ⬭

C XeF_4 ⬭

D PCl_4^+ ⬭

(Total 1 mark)

Q5.

Sodium thiosulfate reacts with dilute hydrochloric acid as shown.

$$Na_2S_2O_3(aq) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + SO_2\ (g) + S(s) + H_2O(l)$$

(c) Draw a diagram to show the shape of a molecule of H_2O
Include any lone pairs of electrons.

State the H-O-H bond angle.

Explain this shape and bond angle.

Diagram

Bond angle _____

Explanation _____

_____

_____

_____

_____

_____

_____

_____

(4)

Q6.

Ammonia reacts with aluminium chloride as shown by the equation:

$$NH_3 + AlCl_3 \longrightarrow H_3NAlCl_3$$

(a) Draw diagrams to illustrate the shapes of NH_3 molecules and of $AlCl_3$ molecules.

Include in your diagrams any lone pairs of electrons that influence the shape.

Indicate the values of the bond angles.

(3)

(b) Name the type of bond formed between N and Al in H_3NAlCl_3 and explain how this bond is formed.

Type of bond _____

Explanation _____

_____

_____

_____

(2)

(c) Explain how the value of the Cl-Al-Cl bond angle in $AlCl_3$ changes, if at all, on formation of the compound H_3NAlCl_3

_____

_____

_____

_____

(2)

(Total 7 marks)

Q7.

This question is about the element iodine and its compounds.

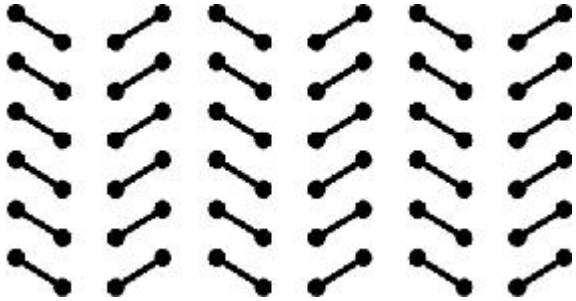
(a) Iodine is in Group 7 of the Periodic Table.

Complete the electron configuration of an iodine atom.

[Kr] _____

(1)

(b) Part of the structure of an iodine crystal is shown in the diagram.



Use your knowledge of structure and bonding to explain why the melting point of iodine is low (113.5 °C) and why that of hydrogen iodide is very low (–50.8 °C).

(6)

(c) State why iodine does **not** conduct electricity.

_____

_____

_____

(1)

(f) Draw the shape of the IF_3 molecule and the shape of the IF_4^- ion.
Include any lone pairs of electrons that influence each shape.

(2)

Q8.

This question is about shapes of molecules and ions.

Draw the shape of NCl_3 and of NCl_4^+

Include any lone pairs of electrons that influence the shape.

Name the shape of NCl_3

State and explain the bond angle in NCl_4^+

Shape of NCl_3 **Shape of NCl_4^+**

Name of shape of NCl_3 _____

Bond angle in NCl_4^+ _____

Explanation of bond angle in NCl_4^+ _____

_____

_____

_____

_____

(Total 5 marks)

Q9.

The melting point of XeF_4 is higher than the melting point of PF_3

Explain why the melting points of these two compounds are different.

In your answer you should give the shape of each molecule, explain why each molecule has that shape and how the shape influences the forces that affect the melting point.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(Total 6 marks)

Q10.

This question is about compounds containing fluorine.

(a) Draw the shape of a molecule of krypton difluoride (KrF_2).
Include in your answer any lone pairs of electrons that influence the shape.
Name the shape produced by the atoms in a KrF_2 molecule and suggest a bond angle.

Name of shape _____

Bond angle _____

(3)

(b) There are two lone pairs of electrons on the oxygen atom in a molecule of oxygen difluoride (OF_2).

Explain how the lone pairs of electrons on the oxygen atom influence the bond angle in oxygen difluoride.

_____

_____

_____

_____

_____

_____

_____

(2)

(c) Silicon tetrafluoride (SiF_4) is a tetrahedral molecule.

Deduce the type of intermolecular forces in SiF_4
Explain how this type of intermolecular force arises and why no other type of intermolecular force exists in a sample of SiF_4

Intermolecular forces in SiF_4 _____

Explanation _____

_____

_____

(3)
(Total 8 marks)

Q11.

This question is about structure and bonding.

(c) Methoxymethane (CH_3OCH_3) is an isomer of ethanol.

The table shows the boiling points of ethanol and methoxymethane.

Compound	**Boiling point / °C**
ethanol	78
methoxymethane	−24

In terms of the intermolecular forces involved, explain the difference in boiling points.

(3)

(c) Draw the shape of the $POCl_3$ molecule and the shape of the ClF_4^- ion.
Include any lone pairs of electrons that influence the shapes.

In a $POCl_3$ molecule the oxygen atom is attached to the phosphorus atom by a double bond that uses two electrons from phosphorus.

Name each shape.

Suggest a value for the bond angle in ClF_4^-

Shape of $POCl_3$ Shape of ClF_4^-

Name of shape of $POCl_3$ _____

Name of shape of ClF_4^- _____

Bond angle in ClF_4^- _____

(5)

(Total 11 marks)

Q12.

This question is about shapes of molecules.

Complete the table below by drawing the shapes of both the AsF_5 and KrF_2 molecules, showing all lone pairs of electrons that influence the shape.

Deduce the bond angle(s) in AsF_5

	AsF_5	**KrF_2**
Diagram of shape		
Bond angle(s)		

(Total 3 marks)

Q13.

This question is about sodium and some of its compounds.

(a) Use your knowledge of structure and bonding to explain why sodium bromide has a melting point that is higher than that of sodium, and higher than that of sodium iodide.

(6)

(d) Sodium reacts with ammonia to form the compound $NaNH_2$ that contains the NH_2^- ion.

Draw the shape of the NH_2^- ion.
Include any lone pairs of electrons that influence the shape.

Predict the bond angle. shape
Justify your prediction.

Bond angle _____Justification
_____- **(4)**

Q1.

D

$FeCl_3$(aq) and concentrated HCl(aq)

[1]

Q2.

A

[1]

Q3.

D

[1]

Q4.

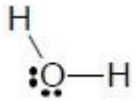
C

XeF_4

[1]

Q5.

(c) **M1**



M1 *bent shape and 2 lone pairs on O*
Allow any suitable representation of lone pairs (e.g. dots, crosses, lobes with/without dots/crosses)

1

M2 104½°

M2 *Allow 104-105°*

1

M3 lone pairs repel more (strongly) than bond(ing) pairs

M3 *Allow non-bonding pair for lone pair*
Allow covalent bond for bond(ing) pair
Allow shared pair for bond(ing) pair
Allow OH bond for bond(ing) pair
Allow bond for bond(ing) pair
NOT OH or O-H without the word bond for bond(ing) pair

1

M4 so bond angle reduced from/less than 109½° / tetrahedral

M4 *Allow bond angle reduced from 120° if bent with one lone pair in* ***M1***

Allow reduced from 109°

Allow reduced by 2.5° per lone pair or 5° if ***M2*** *correct*

1

Q6.

(a) Correct diagram of NH_3 including LP on N

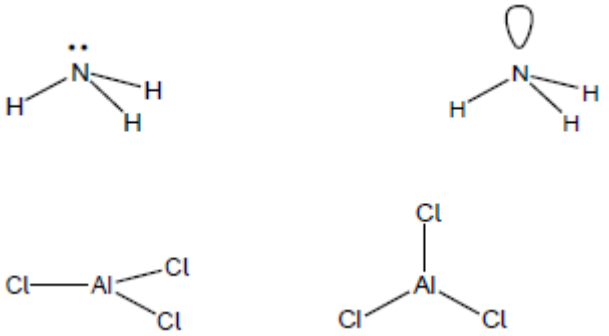
1

Correct diagram of $AlCl_3$

1

Bond angles in range 106-108° and bond angle of 120°

1



Ignore shape names

(b) Dative (covalent) /co-ordinate bond

Wrong bond CE=0 but mark on if covalent quoted

1

Shared pair of / both electrons come from the N(H_3)

1

(c) Aluminium is now surrounded by 4 electron pairs/bonds or is tetrahedral

Independent

1

Therefore Cl-Al-Cl bond angle decreases / changes
(from 120° in $AlCl_3$) to allow range 107-111° in H_3NAlCl_3

1

[7]

Q7.

(a) [Kr] $5s^2$ $4d^{10}5p^5$

1

(b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3
All stages are covered and the explanation of each stage is correct and complete.

Answer communicates the whole explanation coherently and shows a logical progression from stage 1 to stage 2 and then stage 3.

5-6 marks

Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

3-4 marks

Level 1
Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, **OR** only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

1-2 marks

Level 0
Insufficient correct chemistry to warrant a mark.

0 marks

Indicative Chemistry content

Stage 1

I_2 is molecular.

HI is molecular.

Stage 2

IMF hold the molecules together.

There are weak IMF forces hence the melting point is low in both substances.

I_2 bigger molecule than HI so I_2 has more electrons.

Stage 3

Therefore stronger van der Waals between molecules in I_2 that need more energy to break causing the melting point to be higher.

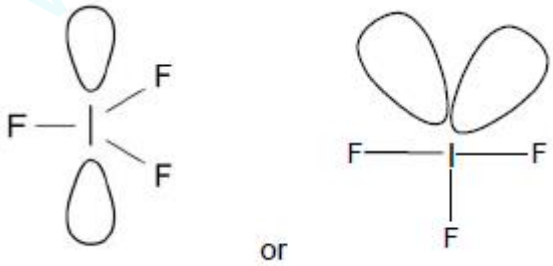
HI also shows permanent dipole-dipole attraction between molecules but these forces are less than the vdW forces in iodine.

6

(c) No delocalised electrons or ions

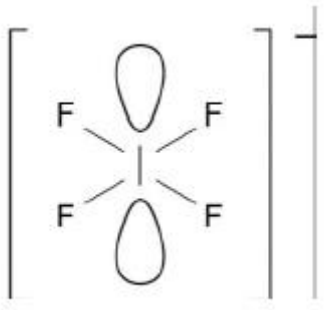
1

(f)



Allow any shape with 3 bond pairs and 2 lone pairs

1



Allow any shape with 4 bond pairs and 2 lone pairs (e.g. lone pairs in equatorial positions)

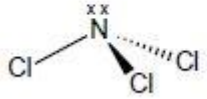
1

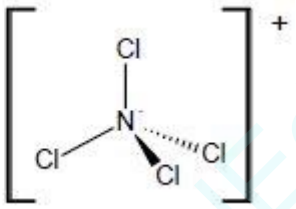
Q8.

Shapes:

Must show lp on NCl_3

1





Must have some indication that shape is 3D

1

Name of shape of NCl_3 = Pyramidal

Allow tetrahedral

1

Bond Angle = 109.5°

Allow 109 – 109.5°

1

(4 bp and 0 lp) electron pairs repel equally / electron pairs repel to be as far apart as possible

Do not allow atoms repel equally

Allow bonds repel equally

1

[5]

Q9.

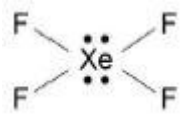
This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.	
Level 3 **5-6 marks**	All stages are covered and the description of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and stage 3.

Level 2 **3-4 marks**	All stages are covered but the description of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete. Answer is mainly coherent and shows progression from stage 1 to stage 2 and/or stage 3.
Level 1 **1-2 marks**	Two stages are covered but the description of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete. Answer includes isolated statements and these are presented in a logical order.
Level 0 **0 marks**	**0 marks** Insufficient correct chemistry to gain a mark.

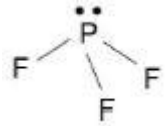
Indicative chemistry content

<u>Stage 1 electron pairs</u>
1a XeF_4 4BP and 2LP around Xe
1b PF_3 3BP and 1LP around P

Stage 2 explanation of shapes
2a XeF_4 is square planar
Or



2b PF_3 is pyramidal (allow tetrahedral)
Or

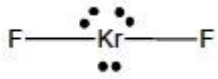


2c Electron pairs repel as far as possible or Lone pair repels more than bonding pairs

Stage 3 IMF
The relative strength of the intermolecular forces in the molecules must be explained to gain maximum marks.
3a XeF_4 has vdw forces and PF_3 has dipole-dipole forces (and vdw)
3b Stronger/more intermolecular forces in XeF_4
3c Due to larger M_r or more electrons or larger molecules or packs more closely together

[6]

Q10.

(a) 

Allow diagram with 2 bonds <u>and</u> 3 lone pairs

1

<u>Linear</u>

1

180°

1

(b) Lone pairs repel more than bond pairs

1

Allow idea of reducing bond angle

bond angle will be lower (than regular tetrahedral angle) / bond angle of 103-106°

1

(c) Van der Waals forces

Allow London forces, dispersion forces, induced dipole-dipole

Apply List for M1.

Allow M2 if vdW mentioned in M1, otherwise CE=0

1

(Uneven distribution of electrons in) one molecule induces dipole in neighbouring/another/nearby molecule

1

symmetrical molecule / dipoles cancel

OR

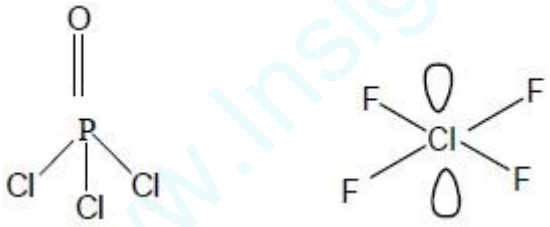
no hydrogens bonded to F (N or O), therefore no hydrogen bonding

1

[8]

Q11.

(c)



$POCl_3$: allow any shape showing 1 double bond between P and O and 3 P-Cl bonds

1

ClF_4^-: allow any shape showing 4 Cl⁻F bonds and 2 lone pairs

1

(distorted) Tetrahedral

1

Square planar

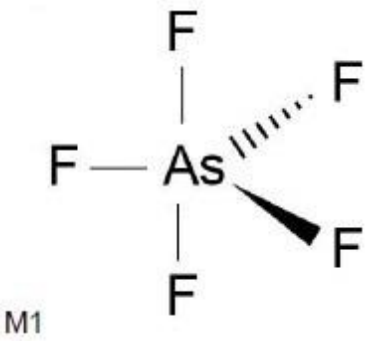
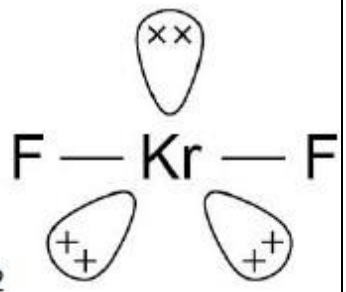
1

90°

1

[11]

Q12.

	AsF_5	KrF_2
Diagram of shape	 M1	 M2
Bond angle(s)	M3: 90 and 120	

KrF_2 must show lone pairs (either as lobes or crosses/dots) and must be linear.

Ignore any lone pairs on fluorine.

[3]

Q13.

This question is marked using Levels of Response. Examiners should apply a 'best-fit' approach to the marking.	
Level 3 5-6 marks	All stages are covered and the explanation of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. Coherent communication requires that there is a comparison between the types of bonding and that the bonding is correct for each substance.
Level 2 3-4 marks	All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete. Answer is mainly coherent and shows some progression from stage 1 to stage 2 and then stage 3.
Level 1 1-2 marks	Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR only one stage is covered but the explanation is generally correct and virtually complete. Answer shows some progression between two stages
Level 0	Insufficient correct chemistry to gain a mark.

0 marks	

Indicative chemistry content. Contradictions (eg molecules, IMFs, covalent bonding,) negate statements.

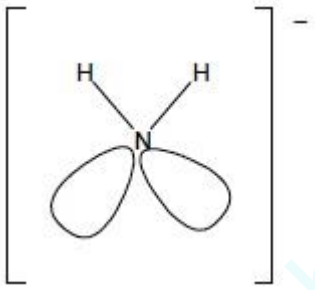
Stage 1 - **Na**
1a) Na has metallic bonding
1b) there is attraction/ bonding between the positive nucleus/ ion and the delocalised electrons in Na
1c) Na has a giant/lattice structure

Stage 2 – **NaBr or NaI**
2a) Ionic bonding in NaBr and/or NaI
2b) There is attraction/ bonding between the + and – ions in NaBr and/or NaI
2c) NaBr and/or NaI have a giant/lattice structure

Stage 2 – **comparison of bonding**
3a) The ionic bonds are stronger (or wtte) than the metallic bonds
3b) there is stronger attraction (or wtte) between the + and – ions in NaBr than in NaI
3c) since the Br^- ion is smaller than the I– ion

6

(d) **M1**



Ignore charge and brackets

1

M2 104.5°

Allow 104-106

1

M3 (4) electron pairs repel to be as far apart as possible

1

M4 lp/lp repulsion> lp/bp repulsion (> bp/bp repulsion)

For M4 allow lone pairs repel more than bonding pairs

Mark independently

1

[16]