

An Introduction to the Chemistry of the Transition Elements

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	An Introduction to the Chemistry of the Transition Elements
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed: 71 minutes

Score: /59

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1 Transition elements have characteristic properties due to their partially-filled d orbitals.

(a) (i) Which **two** elements in the first row of the d-block have only one electron in the 4s orbital of their neutral atoms?

.....

(ii) The d orbitals in an isolated transition metal atom or ion are described as being degenerate.

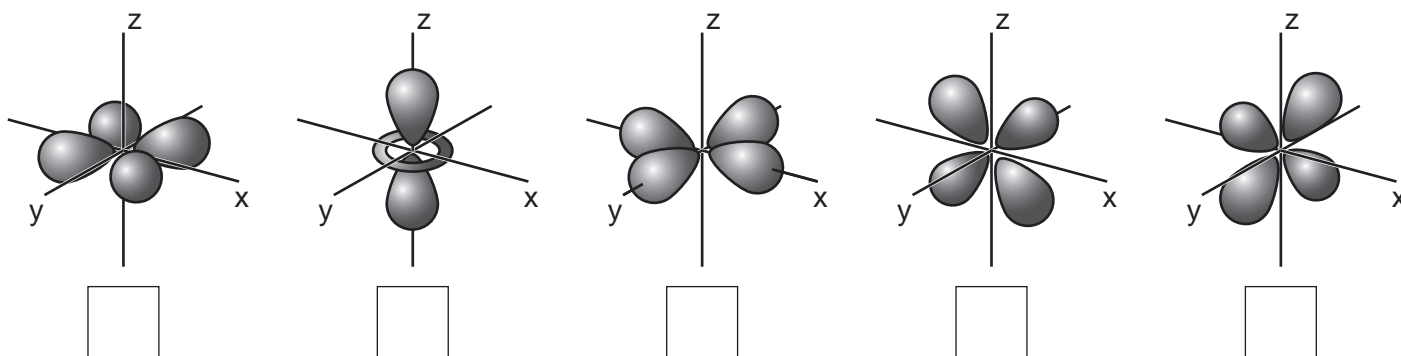
What is meant by the term *degenerate*?

.....

(iii) Sketches of the shapes of the atomic orbitals from the d subshell are shown.

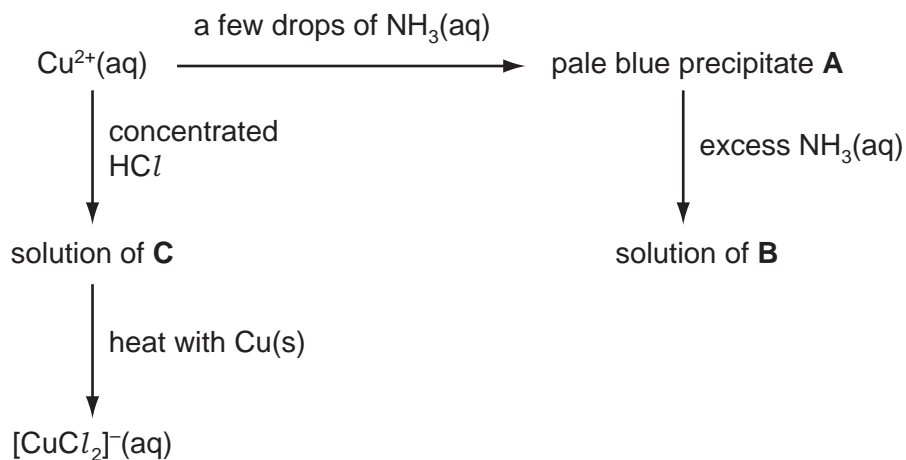
In an octahedral complex, the d orbitals are split into two groups at different energy levels.

On the diagram below, write an 'H' in the box under each of the orbitals at the higher energy level.



[4]

(b) The following scheme shows some reactions of $\text{Cu}^{2+}(\text{aq})$.



(i) Suggest the formula of each of the following.

A

B

C

(ii) State the colour of the following solutions.

solution of B

solution of C

(iii) Name the type of reaction that occurs when C is heated with copper.

.....

Deduce the role of the copper metal in this reaction.

.....

[6]

(c) When the solution containing the complex $[\text{CuCl}_2]^{-}$ is poured into water, a precipitate of CuCl is formed. CuCl is white because it does not absorb visible light.

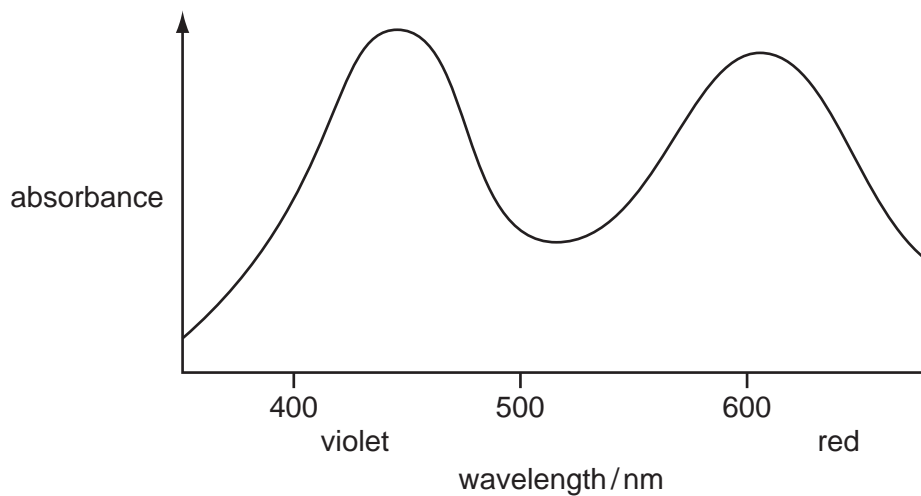
Explain why CuCl does **not** absorb visible light.

.....

.....

..... [2]

- (d) The complex ion $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ is coloured because it **absorbs** visible light. The absorption spectrum for $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ is shown below.



Suggest the colour of this complex ion. Explain your answer.

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

[Total: 14]

2 This question refers to the elements in the section of the Periodic Table shown below.

			H						He	
Li	Be			B	C	N	O	F	Ne	
Na	Mg			Al	Si	P	S	Cl	Ar	
K	Ca	transition elements	Ga	Ge	As	Se	Br	Kr

(a) From this list of elements, identify in **each** case **one** element that has the property described. Give the **symbol** of the element.

(i) An element that floats on cold water and reacts readily with it.

.....

(ii) An element that forms an oxide that is a reducing agent.

.....

(iii) The element that has the smallest first ionisation energy.

.....

(iv) The element which has a giant molecular structure **and** forms an oxide which has a simple molecular structure.

.....

(v) The element in Period 3 (Na to Ar) that has the smallest anion.

.....

(vi) The element in Period 3 (Na to Ar) which forms a chloride with a low melting point and an oxide with a very high melting point.

.....

[6]

(b) Use the elements in Period 3 (Na to Ar) in the section of the Periodic Table opposite to identify the oxide(s) referred to below.

In **each** case, give the **formula** of the oxide(s).

(i) An oxide which when placed in water for a long time has no reaction with it.

.....

(ii) An oxide which dissolves readily in water to give a strongly alkaline solution.

.....

(iii) Two acidic oxides formed by the same element.

..... and

(iv) An oxide which is amphoteric.

.....

[5]

(c) Fluorine reacts with other elements in Group VII to form a number of different compounds. Two such compounds and their boiling points are given in the table.

compound	ClF_3	BrF_3
boiling point/ $^{\circ}\text{C}$	12	127

(i) The two molecules have similar electronic configurations. Showing outer electrons only, draw a 'dot-and-cross' diagram of the bonding in ClF_3 .

(ii) The two molecules have the same shape. Suggest why the boiling points are significantly different.

.....
.....
.....
.....

[4]

[Total: 15]

3 This question refers to the elements in the section of the Periodic Table shown below.

			H						He	
Li	Be			B	C	N	O	F	Ne	
Na	Mg			Al	Si	P	S	Cl	Ar	
K	Ca	transition elements	Ga	Ge	As	Se	Br	Kr

(a) From this list of elements, identify in **each** case **one** element that has the property described. Give the **symbol** of the element.

(i) An element that when placed in cold water sinks and reacts readily.

.....

(ii) An element whose molecules contain π bonding.

.....

(iii) An element that forms a gaseous toxic oxide.

.....

(iv) The element which has a giant molecular structure **and** forms an oxide which also has a giant molecular structure.

.....

(v) An element that forms a covalent chloride which dissolves in water to give a conducting solution.

.....

(vi) The element in Period 3 (Na to Ar) with the greatest electrical conductivity.

.....

[6]

(b) Some of the elements in Period 3 (Na to Ar) burn with a coloured flame when heated in oxygen or chlorine.

(i) Give the symbol of **one** such element, the formula of the **oxide** formed, and state the flame colour that would be seen.

symbol of element

formula of oxide

flame colour

(ii) For the element you have used in (i), give the formula of the chloride formed, and state the pH of the solution produced when this chloride is shaken with water.

formula of chloride

pH of solution

[4]

(c) Chlorine reacts with both bromine and iodine to form BrCl and ICl respectively. The melting points of chlorine and the two chlorides are shown in the table.

substance	Cl_2	BrCl	ICl
m.p./°C	-101	-66	24

(i) Showing outer electrons only draw a 'dot-and-cross' diagram of the bonding in ICl .

(ii) Suggest why the melting points increase from Cl_2 to ICl .

.....

(iii) Suggest which of these three molecules has the largest permanent dipole. Explain your answer.

.....

[5]

[Total: 15]

4 This question refers to the elements in the section of the Periodic Table shown below.

		H						He		
Li	Be			B	C	N	O	F	Ne	
Na	Mg			Al	Si	P	S	Cl	Ar	
K	Ca	transition elements	Ga	Ge	As	Se	Br	Kr

(a) From this list of elements, identify in **each** case **one** element that has the property described. Give the **symbol** of the element.

(i) An element that has molecules which consist of single atoms.

.....

(ii) An element that has a molecule which contains exactly four atoms.

.....

(iii) The element that is a liquid at room temperature and pressure.

.....

(iv) The element in Period 3 (Na to Ar) that has the largest atomic radius.

.....

(v) The element in Period 3 (Na to Ar) that has the highest melting point.

.....

(vi) The element in Period 3 (Na to Ar) that forms the largest anion.

.....

(vii) An element that reacts with water to give a solution that can behave as an oxidising agent.

.....

[7]

- (b) The formulae and melting points of some of the oxides of the elements in Period 3, Na to Cl, are given in the table.

formula of oxide	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₆	SO ₂	Cl ₂ O ₇
m.p./°C	1132	2830	2054	1710	24	-73	-92

- (i) Give the formulae of **two** of these oxides that have simple molecular structures.

..... and

- (ii) Give the formula of one of these oxides that will give no reaction with water when placed in it for a long time.

.....

- (iii) Give the formula of the product formed when MgO is reacted with SO₂.

.....

[4]

- (c) The melting points of the elements Si to Cl are given in the table.

element	Si	P	S	Cl
m.p./°C	1414	44	115	-102

- (i) Explain why the melting point of Si is very much greater than those of the other three elements.

.....

- (ii) Suggest why the melting points of the other three elements are in the order S > P > Cl.

.....

[4]

[Total: 15]