The Periodic Table: Chemical Periodicity

Question Paper 8

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	The Periodic Table: Chemical Periodici
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 8

Time Allowed: **64 minutes**

Score: **/53**

Percentage: **/100**

Grade Boundaries:

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

1 The ions of transition elements form *complexes* by reacting with *ligands*.

(a) State what is meant by the terms:

complex, ...

.....

ligand. .....

.....

(ii) Two of the complexes formed by copper are $[Cu(H_2O)_6]^{2+}$ and $CuCl_4^{2-}$.
Draw three-dimensional diagrams of their structures in the boxes and name their shapes.

$[Cu(H_2O)_6]^{2+}$	$CuCl_4^{2-}$
shape:	shape: .....

(iii) Platinum forms square-planar complexes, in which all four ligands lie in the same plane as the Pt atom.
There are two isomeric complexes with the formula $Pt(NH_3)_2Cl_2$.
Suggest the structures of the two isomers, and, by comparison with a similar type of isomerism in organic chemistry, suggest the type of isomerism shown here.

Structures of isomers:

isomer 1	isomer 2

Type of isomerism: .....

[7]

(b) Copper forms two series of compounds, one containing copper(II) ions and the other containing copper(I) ions.

(i) Complete the electronic structures of these ions.

Cu(II) [Ar] .....

Cu(I) [Ar] .....

(ii) Use these electronic structures to explain why

copper(II) salts are usually coloured,

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.....

.....

.....

copper(I) salts are usually white or colourless.

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.....

[5]

(c) Copper(I) oxide and copper(II) oxide can both be used in the ceramic industry to give blue, green or red tints to glasses, glazes and enamels.

The table lists the $\Delta H_f^\ominus$ values for some compounds.

compound	$\Delta H_f^\ominus$ / kJ mol^{-1}
$Cu_2O(s)$	–168.6
$CuO(s)$	–157.3
$Cu(NO_3)_2(s)$	–302.9
$NO_2(g)$	+33.2

(i) Copper(II) oxide can be produced in a pure form by heating copper(II) nitrate. Use suitable $\Delta H_f^\ominus$ values from the table to calculate the $\Delta H^\ominus$ for this reaction.

$$Cu(NO_3)_2(s) \rightarrow CuO(s) + 2NO_2(g) + \tfrac{1}{2}O_2(g)$$

$\Delta H^\ominus$ = ... kJ mol^{-1}

(ii) Copper(I) oxide can be produced from copper(II) oxide.

- Use suitable $\Delta H_f^\ominus$ values from the table to calculate $\Delta H^\ominus$ for the reaction.

$$2CuO(s) \rightleftharpoons Cu_2O(s) + \tfrac{1}{2}O_2(g)$$

$\Delta H^\ominus$ = ... kJ mol^{-1}

- Hence suggest whether a low or a high temperature of oxidation would favour the production of copper(I) oxide. Explain your reasoning.

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.....

[4]

[Total: 16]

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 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.

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.....

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

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[5]

[Total: 15]

3 **(a)** **(i)** What is meant by the term *lattice energy*?

.....

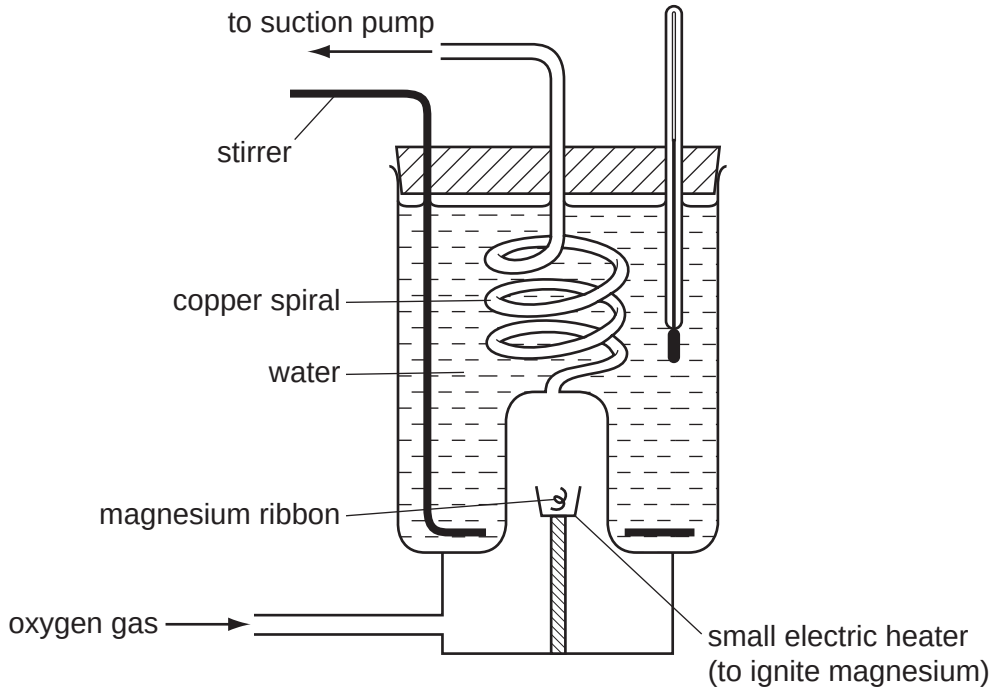
.....

(ii) Write an equation to represent the lattice energy of MgO.

.....

[3]

(b) The apparatus shown in the diagram can be used to measure the enthalpy change of formation of magnesium oxide, $\Delta H_f^{\ominus}$(MgO).



List the measurements you would need to make using this apparatus in order to calculate $\Delta H_f^{\ominus}$(MgO).

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..... [3]

(c) Use the following data, together with appropriate data from the *Data Booklet*, to calculate a value of $\Delta H_f^{\ominus}$(MgO).

lattice energy of MgO(s)	=	–3791 kJ mol^{-1}
enthalpy change of atomisation of Mg	=	+148 kJ mol^{-1}
electron affinity of the oxygen atom	=	–141 kJ mol^{-1}
electron affinity of the oxygen anion, O^-	=	+798 kJ mol^{-1}

$\Delta H_f^{\ominus}$(MgO) = ... kJ mol^{-1}
[3]

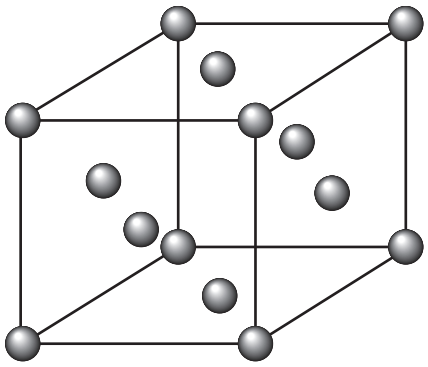
(d) Write equations, including state symbols, for the reactions, if any, of the following two oxides with water. Suggest values for the pH of the resulting solutions.

oxide	equation	pH of resulting solution
Na_2O		
MgO		

[3]

[Total: 12]

4 Copper, proton number 29, and argon, proton number 18, are elements which have different physical and chemical properties.
In the solid state, each element has the same face-centred cubic crystal structure which is shown below.



The particles present in such a crystal may be atoms, molecules, anions or cations. In the diagram above, the particles present are represented by ●.

(a) Which types of particle are present in the copper and argon crystals?
In each case, give their formula.

element	particle	ormula
copper		
argon		

[2]

At room temperature, copper is a solid while argon is a gas.

(b) Explain these observations in terms of the forces present in **each** solid structure.

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.....

..... [4]

Although copper is a relatively unreactive element, when it is heated to a high temperature in an excess of chlorine, copper(II) chloride is formed.

When a mixture of argon and chlorine is heated to a high temperature, no reaction occurs.

(c) (i) How does chlorine behave in its reaction with copper?

.....

(ii) Suggest a reason for the lack of a reaction between argon and chlorine.

.....

.....
[2]

The melting points of the noble gases neon to xenon are given below.

	Ne	Ar	Kr	Xe
melting point/K	25	84	116	161

(d) Explain why there is an increase in melting point from neon to xenon.

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..... [2]

[Total: 10]