The Periodic Table: Chemical Periodicity

Question Paper 5

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	The Periodic Table: Chemical Periodici
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 5

Time Allowed: **65 minutes**

Score: **/54**

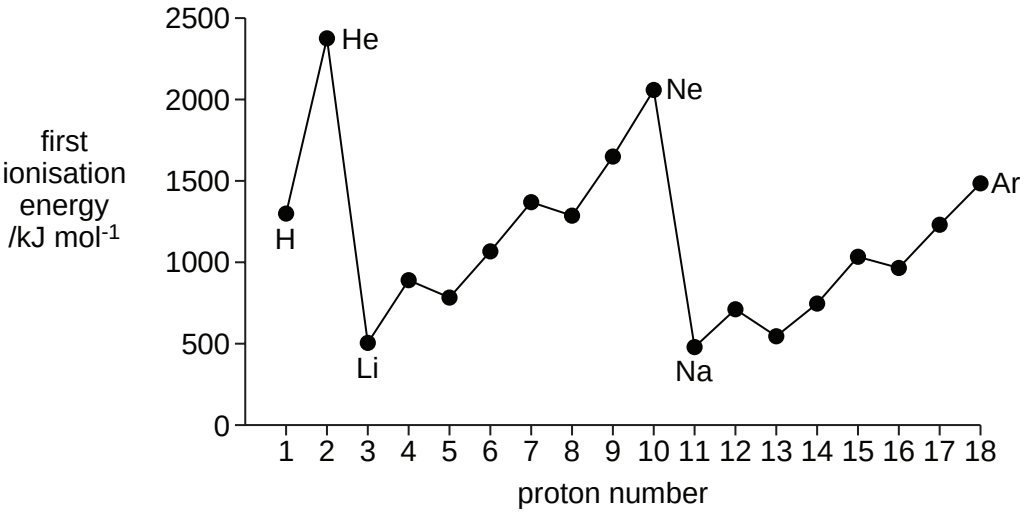
Percentage: **/100**

Grade Boundaries:

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

1 The Periodic Table we currently use is derived directly from that proposed by Mendeleev in 1869 after he had noticed patterns in the chemical properties of the elements he had studied.

The diagram below shows the first ionisation energies of the first 18 elements of the Periodic Table as we know it today.



(a) Give the equation, including state symbols, for the first ionisation energy of fluorine.

.....[2]

(b) Explain why there is a general increase in first ionisation energies from sodium to argon.

.....

.....

.....

.....[3]

(c) **(i)** Explain why the first ionisation energy of aluminium is less than that of magnesium.

.....

.....

.....

(ii) Explain why the first ionisation energy of sulphur is less than that of phosphorus.

.....

.....

.....
[4]

The table below refers to the elements sodium to sulphur and is incomplete.

element	Na	Mg	Al	Si	P	S
melting point		high				
conductivity		high				

(d) **(i)** Complete the 'melting point' row by using **only** the words 'high' **or** 'low'.

(ii) Complete the 'conductivity' row by using **only** the words 'high', 'moderate' **or** 'low'.
[5]

(e) When Mendeleev published his Periodic Table, the elements helium, neon and argon were not included.

Suggest a reason for this.

.....

.....[1]

[Total: 15]

2 Ethene, C_2H_4, and hydrazine, N_2H_4, are hydrides of elements which are adjacent in the Periodic Table. Data about ethene and hydrazine are given in the table below.

	C_2H_4	N_2H_4
melting point/°C	–169	+2
boiling point/°C	–104	+114
solubility in water	insoluble	high
solubility in ethanol	high	high

(a) Ethene and hydrazine have a similar arrangement of atoms but differently shaped molecules.

(i) What is the H-C-H bond angle in ethene?

.....

(ii) Draw a 'dot-and-cross' diagram for hydrazine.

(iii) What is the H-N-H bond angle in hydrazine?

.....

[4]

(b) The melting and boiling points of hydrazine are much higher than those of ethene. Suggest reasons for these differences in terms of the intermolecular forces **each** compound possesses.

.....

.....

.....

.....

.....[3]

(c) Explain, with the aid of a diagram showing lone pairs of electrons and dipoles, why hydrazine is very soluble in ethanol.

[3]

Ethene and hydrazine each react with HC*l*.

(d) When ethene is reacted with HC*l*, C_2H_5Cl is the only product.

(i) Using structural formulae, give an equation for the reaction between ethene and HC*l*.

(ii) What type of reaction occurs between HC*l* and ethene?

.....

(iii) Explain why there is no further reaction between C_2H_5Cl and HC*l*.

.....

[3]

(e) When aqueous hydrazine is reacted with HC*l*, a solid compound of formula N_2H_5Cl may be isolated. When an excess of HC*l* is used, a second solid, $N_2H_6Cl_2$, is formed.

(i) Suggest what type of reaction occurs between hydrazine and HC*l*.

.....

(ii) What feature of the hydrazine molecule enables this reaction to occur?

.....

(iii) Suggest why one molecule of hydrazine is able to react with one or two molecules of HC*l*.

.....

.....

[3]

[Total: 16]

3 Carbon forms two stable oxides, CO and CO_2. Lead forms three oxides: yellow PbO, black PbO_2 and red Pb_3O_4.

(a) Carbon monoxide burns readily in air. Heating black lead oxide produces oxygen gas, leaving a yellow residue.

(i) Suggest a balanced equation for **each** reaction.

.....

.....

(ii) Explain how these two reactions illustrate the relative stabilities of the +2 and +4 oxidation states down Group IV.

.....

.....

[3]

(b) Red lead oxide contains lead atoms in two different oxidation states.

(i) Suggest what these oxidation states are, and calculate the ratio in which they occur in red lead oxide.

.....

.....

(ii) Predict the equation for the action of heat on red lead oxide.

.....

When red lead oxide is heated with dilute nitric acid, HNO_3, a solution of lead(II) nitrate is formed and a black solid is left.

(iii) Suggest an equation for this reaction.

.....

(iv) Explain how this reaction illustrates the relative basicities of the two oxidation states of lead.

.....

.....

[5]

(c) Both tin(II) oxide and tin(IV) oxide are amphoteric.

Write a balanced equation for the reaction between tin(II) oxide and aqueous sodium hydroxide.

.....[1]

[Total: 9]

4 This question concerns the chlorides of the elements sodium to phosphorus of the third period of the Periodic Table.
The melting points of these chlorides are given below.

compound	sodium chloride	magnesium chloride	aluminium chloride	silicon tetrachloride	phosphorus(V) chloride
melting point/K	1081	987	451*	203	435

*sublimes at 451 K

(a) Give the equation, with state symbols, for the reaction of phosphorus with chlorine to form phosphorus(V) chloride, PCl_5.

.....[2]

(b) Suggest, in terms of the structure and bonding, explanations for the following.
You should draw diagrams where you think they will help your answer.

(i) the high melting point of sodium chloride

(ii) the low melting point of silicon tetrachloride

[4]

(c) Write an equation for the reaction of silicon tetrachloride with water.

.....[1]

(d) What is the pH of the solution formed when **each** of the following compounds is dissolved in water?

NaC*l* .....

PCl_5 ..... [2]

(e) When solid aluminium chloride is heated above 451 K, a vapour is formed which has M_r = 267.
When this vapour is heated above 1100 K, the vapour has M_r = 133.5.

(i) What are the molecular formulae of these two forms of aluminium chloride?

at 460 K ..... at 1150 K .....

(ii) Draw a 'dot-and-cross' diagram of the form of aluminium chloride that exists at the **higher** temperature.

(iii) Draw a displayed formula of the form of aluminium chloride that exists at the **lower** temperature. Indicate clearly the different types of bonds present.

[5]

[Total: 14]