

The Periodic Table

Mark Scheme



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1. The periodic table arranges all of the known chemical elements in order of increasing atomic number, organising them into vertical groups and horizontal periods to reveal clear trends in their atomic structure and properties. Circle the letter of the correct answer for each of the following questions.

- a. A neutral sodium atom has 11 electrons.

Which of the following statements about sodium is correct?

B – is the only correct answer.	(1)
	Total: 1 mark

- b. What is the element that is in period 3 and group 2 of the Periodic Table?

A – is the only correct answer.	(1)
	Total: 1 mark

- c. A version of the Periodic Table is shown in the figure below.

Which element is used as a catalyst?

S – is the only correct answer.	(1)
	Total: 1 mark

- d. Which property of elements increases across a period of the Periodic Table?

B – is the only correct answer.	(1)
	Total: 1 mark

- e. Which statement about elements in Group I and Group VII of the Periodic Table is correct?

B – is the only correct answer.	(1)
	Total: 1 mark

(Total for Question 1 is 5 marks)

2. The figure below shows part of the modern Periodic Table.

I	II											III	IV	V	VI	VII	VIII
																	He
Na	Mg											Al	C	N	O		
K	Ca						Fe				Cu					Br	
																I	

Use only the elements shown in the figure above to answer the following questions.
Give the symbol for the element in each case.

a. Which element is the most abundant gas in clean, dry air?

N – is the only correct answer.	(1)
	Total: 1 mark

b. Which element shown has a stable electron arrangement with a full outer shell?

He – is the only correct answer.	(1)
	Total: 1 mark

c. Identify the element located in the fifth period of the periodic table.

I – is the only correct answer.	(1)
	Total: 1 mark

d. Which element's atoms typically gain two electrons to achieve a full outer shell?

O – is the only correct answer.	(1)
	Total: 1 mark

e. When tested with sodium hydroxide solution, a solution containing ions of this element forms a green solid. Name the element.

Iron. Allow Fe.	(1)
	Total: 1 mark

f. Name the element used for making items like drink cans and kitchen foil because it is protected by a strong, unreactive oxide layer.

Aluminium. Allow Al.	(1)
	Total: 1 mark

3. The elements in Group 1 of the periodic table, known as the alkali metals, show clear trends in their properties. The table below shows data for the first three elements in Group 1.

Element	Boiling point (°C)	Atomic radius (pm)	Relative thermal conductivity	Reaction in Water
Lithium	1,342		2.4	fizzes steadily
Sodium	883	186	3.8	rapid bubbling but does not burst into flame.
Potassium	759	227	1.6	very rapid bubbling and bursts into flame
Rubidium	688	248		explodes

- a. The table below has two missing pieces of data.

- i. Suggest a value for the atomic radius of Lithium.

Any value between 120 and 180 (pm). Allow any value less than 186 (pm)	(1)
	Total: 1 mark

- ii. Suggest a value for the thermal conductivity of Rubidium.

Any value lower than 1.6. Allow: any value between 0.5 and 1.5	(1)
	Total: 1 mark

- b. The reactivity of the alkali metals **increases** as you go down the group from lithium to caesium.

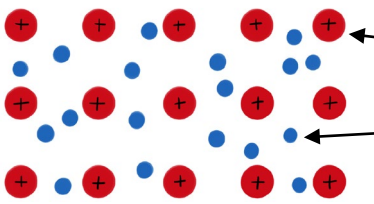
Explain this trend in terms of atomic structure.

An explanation to include:	
(As you go down the group) the atom is larger / has more shells / outer electron is further from the nucleus.	(1)
The outer electron is less attracted to the nucleus.	(1)
There is more shielding.	(1)
(So) the outer electron is lost more easily.	(1)
Allow less energy is needed to remove the electron	
	Total: 3 marks

Magnesium is a metal found in Group 2 of the Periodic Table.

- c. Describe the structure and bonding in a metal.

You **may** include a diagram in your answer.

 Lattice of positive metal ions. Sea of delocalised electrons. Award both marks for a correct labelled diagram. Allow any correct version.	
(Giant) lattice of positive ions.	(1)
(Surrounded by / sea of) delocalised electrons.	(1)
	Total: 2 marks

The element caesium (Cs) has a proton number of 55 and is radioactive.

- d. What is meant by the term proton number?

The number of protons (in the nucleus of the atom). number.	Allow atomic	(1)
		Total: 1 mark

- e. A student investigates the reaction between sodium hydride and iron(III) oxide.
The chemist starts to write out the balanced equation but leaves two gaps.

Balance the equation.

$\text{Fe}_2\text{O}_3 (\text{s}) + 3\text{NaH} (\text{s}) \rightarrow \textcolor{red}{2}\text{Fe} (\text{s}) + \textcolor{red}{3}\text{NaOH} (\text{l})$	$\textcolor{red}{(2)}$
$\textcolor{red}{\text{Allow 1 mark for each correct value.}} \qquad \qquad \textcolor{red}{\text{Allow multiples.}}$	
	$\textcolor{red}{\text{Total: 2 marks}}$

Look at the formula for iron(III) oxide (Fe_2O_3) and the formula for iron (Fe).

- f. **State** what has been lost from the iron(III) oxide to show it has been reduced.

Oxygen.	Allow O or oxide ions.	(1)
		Total: 1 mark

Hydrogen's position in the periodic table is unique.

- g. Explain **one** similarity between hydrogen and the Group 1 elements, and one key difference that sets it apart from them.

Compare NaOH and HCl	
Similarity – any one of the following:	
- Both have one electron in the outer shell / energy level. - Both form +1 ions.	(1)
Difference: any one of the following:	
- Hydrogen is a non-metal / gas (at room temperature). - Hydrogen forms covalent bonds / does not form metallic bonds.	(1)
	Total: 2 marks

(Total for Question 2 is 6 marks)

4. The modern periodic table is based on an earlier version by Dmitri Mendeleev.
As you can see in the figure below, a key feature of his table was that he left gaps for elements that had not yet been discovered.

I						
H	II	III	IV	V	VI	VII
Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl
K	Ca		Ti	V	Cr	Mn
Cu	Zn			As	Se	Br
Rb	Sr	Y	Zr	Nb	Mo	
Ag	Cd	In	Sn	Sb	Te	I
Ce	Ba	La		Ta	W	
Au	Hg	Pt	Pb	Bi		

- a. Identify **two** key features of the way elements were organised in Mendeleev's original periodic table.

Any two of the following:	
- Arranged in order of atomic weight / atomic mass. - Left gaps for elements that had not been discovered. - Grouped elements with similar (chemical) properties. - Swapped the order of some pairs of elements (so their properties fitted the group they were in).	
	Total: 2 marks

- b. Describe how the elements are arranged in the modern Periodic Table.

A description to include:	
Arranged in order of atomic number / proton number.	(1)
Elements with the same number of outer shell electrons are in the same group.	(1)
	Total: 2 marks

- c. The table below shows the properties Mendeleev predicted for an element he called 'eka-aluminium'.

Appearance	Soft, silver metal
Melting point (°C)	Low
Relative atomic mass	68
Density (g/cm ³)	6.0

The next table shows the actual properties of some elements that were discovered later.

	Zinc (Zn)	Gallium (Ga)	Germanium (Ge)	Arsenic (As)
Appearance	Silver-grey metal	Silver-blue metal	Grey-white metal	Grey metalloid
Melting point (°C)	420	30	947	817
Relative atomic mass	65.4	69.7	72.6	74.9
Density (g/cm ³)	7.1	5.9	5.35	5.7

- i. Use the data in both tables to identify which of the discovered elements is **eka-aluminium**.

Gallium / Ga.	(1)
	Total: 1 mark

- ii. Give **two** reasons for your choice, using data from the tables to support your answer.

Any two from the following:	
(Predicted) mass of 68 is very close to 69.7. (Predicted) density of 6.0 is very close to 5.9. (Predicted) low melting point matches (actual) melting point of 30 °C. - Both are silver metals.	
	Total: 2 marks

- d. Argon (Ar) is an unreactive gas that was discovered after Mendeleev created his periodic table.
Its electron arrangement is 2,8,8.

- i. Describe the reactivity of argon.

It is unreactive / inert. Allow: it does not react.	(1)
	Total: 1 mark

- ii. Explain why argon has this level of reactivity. Refer to its electron arrangement in your answer.

An explanation to include:	
(Argon atoms have) a full outer shell (of electrons).	(1)
(So) they do not need to lose, gain or share electrons.	(1)
(So) the electron arrangement is stable.	(1)
	Total: 2 marks

(Total for Question 3 is 13 marks)

5. The table below shows some information about the first four elements in Group 7.

Element	Symbol	State at Room Temperature	Boiling Point (°C)
Fluorine	F	Gas	-188
Chlorine	Cl	Gas	-35
Bromine	Br	Liquid	59
Iodine	I		184

- a. Complete the table to state the physical state of iodine at room temperature (25°C).

Solid.	(1)
	Total: 1 mark

- b. Describe and explain the trend in the boiling points of the halogens as you go down Group 7.

A description to include:	
(Boiling point) increases (down the group).	(1)
(Because) the relative molecular mass increases / the size of the molecule increases.	(1)
(Because) intermolecular forces increase (in strength).	(1)
	Total: 2 marks

- c. The reactivity of the halogens **decreases** as you go down the group from fluorine to iodine.

Explain this trend in terms of atomic structure.

An explanation to include:	
(Outer shell) electrons are further from the nucleus.	(1)
Atomic radius increases.	(1)
There is more shielding (from inner shells).	(1)
(So) the nucleus has less attraction for the incoming electron / it is harder to gain an electron.	(1)
	Total: 3 marks

- d. Chlorine gas is bubbled through a solution of potassium iodide. A displacement reaction occurs.

- i. Name the substance that is displaced from the solution.

Iodine.	(1)
	Total: 1 mark

- ii. Complete the balanced symbol equation for this reaction.

$\text{Cl}_2 (\text{g}) + 2\text{KI} (\text{aq}) \rightarrow 2\text{KCl} (\text{aq}) + \text{I}_2 (\text{aq})$	(2)
Award 1 mark for each correct product.	
	Total: 2 marks

(Total for Question 5 is 9 marks)

6. The central block of the periodic table contains the transition metals. Iron (Fe) and copper (Cu) are two examples.
- a. State **three** properties of transition metals that are different from the properties of the Group 1 alkali metals.

Any three from:	
- Transition metals have higher melting points. - Transition metals are denser / have higher density. - Transition metals are harder / stronger. - Transition metals are less reactive (e.g. with water/oxygen). - Transition metals form ions with different charges. - Transition metals are used as catalysts.	
	Total: 3 marks

The table below shows the appearance of some different metal compounds when dissolved in water.

Compound	Colour of Aqueous Solution
Sodium Chloride	Colourless
Copper(II) Sulfate	Blue
Iron(III) Chloride	Yellow

- b. What property of transition metal ions allows them to form coloured compounds?

They form ions with different charges.	(1)
Allow: they have variable oxidation states. Allow: variable valency	
	Total: 1 mark

- c. Transition metals are often used as catalysts in industrial processes.

- i. What is the role of a catalyst in a chemical reaction?

A catalyst speeds up / increases the rate of a chemical reaction.	(1)
Without being used up / changed.	(1)
It lowers the activation energy for a reaction.	(1)
It provides an alternative reaction pathway.	(1)
	Total: 2 marks

- ii. Name a transition metal used as a catalyst and the industrial process it is used in.

Transition metal: Iron.	(1)
Process: Haber Process / making ammonia.	(1)
Transition metal: Nickel.	(1)
Process: Hydrogenation.	(1)
Transition metal: Vanadium.	(1)
Process: Contact Process.	(1)
	Total: 2 marks

(Total for Question 6 is 8 marks)