Periodicity

1. This question is about magnesium, bromine and magnesium bromide.

Table 16.1 shows some physical properties of magnesium, bromine and magnesium bromide.

Substance	Melting point / °C	Electrical conductivity	
		Solid	Liquid
Magnesium	711	Good	Good
Bromine	−7	Poor	Poor
Magnesium bromide	650	Poor	Good

Table 16.1

Explain the physical properties shown in **Table 16.1** using your knowledge of structure and bonding.

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[6]

2(a). This question is about some elements in Period 4 of the periodic table.

The table shows the melting point and electrical conductivity of two elements in Period 4.

Element	Melting Point / °C	Electrical conductivity
Calcium	842	Good
Bromine	–7	Poor

Use your knowledge of structure and bonding to explain the properties in the table.

[5]

(b). Calcium reacts with bromine to form calcium bromide, $CaBr_2$.

i. Draw a '*dot-and-cross*' diagram to show the bonding in $CaBr_2$.

Show **outer** electrons only.

[2]

ii. The reaction of barium with bromine is more vigorous than the reaction of calcium with bromine.

Explain why.

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[3]

3. The table below shows two physical properties of the element strontium.

Melting point	high
Electrical conductivity	very good

Explain these physical properties of strontium, in terms of bonding and structure.
Include a labelled diagram in your answer.

Diagram

Explanation

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[5]

4. Sir Humphry Davy discovered several elements including sodium, potassium, magnesium, calcium and strontium.

Explain which block in the Periodic Table sodium and magnesium belong to.

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[1]

5. SiO_2 and CO_2 are oxides of Group 14 (Group 4) elements.

Solid SiO_2 melts at 2156 °C. Solid CO_2 melts at −56 °C.

Suggest the type of lattice structure in solid SiO_2 and in solid CO_2 and explain the difference in melting points in terms of the types of force within each lattice structure.

Structure in $SiO_2(s)$

Structure in $CO_2(s)$

Explanation

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[4]

6. Why are silicon, carbon, oxygen and chlorine all classified as p-block elements?

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[1]

7(a). This question refers to the elements in the first three periods (H → Ar) of the Periodic Table.

Select an element from the first three periods that fits each of the following descriptions.

i. The element that forms a 1− ion with the same electron configuration as helium.

[1]

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ii. The element with the highest first ionisation energy.

[1]

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iii. The element in Period 3 which has the successive ionisation energies shown below.

Ionisation number	1st	2nd	3rd	4th
Ionisation energy/kJ mol^{-1}	738	1451	7733	10541

[1]

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iv. The element which forms a compound with fluorine that has octahedral molecules.

[1]

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v. An element which reacts with water to form an acidic solution.

[1]

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vi. The element **X**, which forms a compound with hydrogen, $\mathbf{X}H_3$, with a molar mass of 34.0 g mol^{-1}.

[1]

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vii. An element which forms a compound with hydrogen in which the element has an oxidation number of −4.

[1]

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viii. The element which has a density of 1.33×10^{-3} g cm^{-3} at room temperature and pressure.

[1]

(b). **Table 1.1** shows some properties of Period 3 chlorides.

Group		**1**	**2**	**14 (4)**	**15 (5)**	**16 (6)**
Chloride	NaCl	$MgCl_2$	$SiCl_4$	PCl_3	SCl_2	
Electrical conductivity	**Solid**	poor	poor	poor	poor	poor
	Liquid	good	good	poor	poor	poor
Melting point		high	high	low	low	low

Table 1.1

Explain the properties shown in **Table 1.1** in terms of bonding and structure.

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[5]

8. The table below compares the properties of sodium sulfide, sodium and sulfur.

Complete the table.

		Sodium sulfide	**Sodium**	**Sulfur**
Melting point / °C		1180	98	113
Type of structure (**giant** or **simple**)				
Electrical conductivity (**good** or **poor**)	solid			
	liquid			

[3]

9. The reactivity of the Group 2 elements Mg–Ba increases down the group.

Explain why.

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[3]

10. **B** and **C** are ionic compounds of two different Group 1 elements.
The molar masses of **B** and **C** are both approximately 140 g mol^{-1}.

A student dissolves **B** and **C** in water in separate test tubes and analyses the solutions.

The observations are shown below.

Test	**Observation**	
	B(aq)	**C(aq)**
Addition of HNO_3(aq) followed by $BaCl_2$(aq)	bubbles no change	no change white precipitate

Use this information and the observations to identify the formulae of **B** and **C**.

Explain your reasoning.

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[5]

11. Ionisation energies have been used to develop a model for electron configuration.

i. **Fig. 16.1** shows the first ionisation energies for Li, Be, F and Ne.

Add points for the missing elements across Period 2.

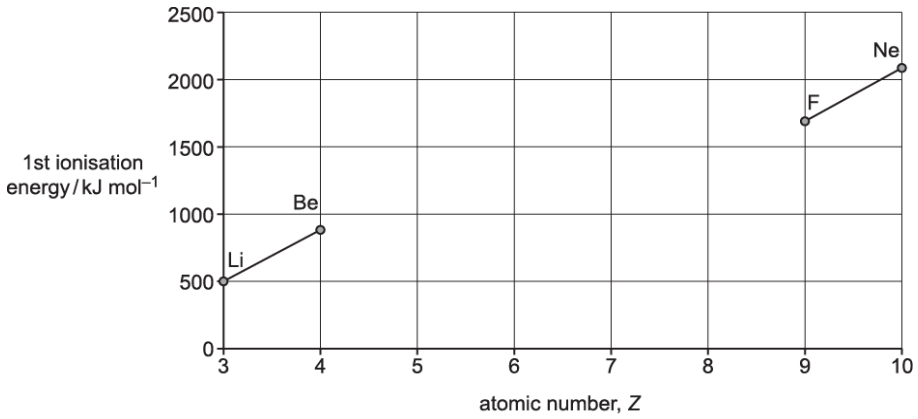

Fig. 16.1

[2]

ii. First ionisation energies decrease down groups in the Periodic Table.

Explain this trend and the effect on the reactivity of groups containing metals.

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[3]

12(a). The elements of Period 2 and Period 3 of the Periodic Table are shown in **Table 3.1**.

Group	1	2	3	4	5	6	7	0
Period 2	Li	Be	B	C	N	O	F	Ne
Period 3	Na	Mg	A*l*	Si	P	S	C*l*	Ar

Table 3.1

The elements in these two periods show a repeating pattern in chemical and physical properties.

What is the name given to this repeating pattern of properties?

_____ **[1]**

(b). State the element in **Table 3.1** with:

- the lowest first ionisation energy
  .....
- the lowest fourth ionisation energy
  .....
- the lowest boiling point
  .....

[3]

(c). The melting points of the Period 3 metals sodium and magnesium are shown below.

Metal	**Melting point / °C**
sodium	98
magnesium	649

Explain the differences in the melting points of sodium and magnesium, using the model of metallic bonding.

In your answer you should use appropriate technical terms spelled correctly.

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_____

_____

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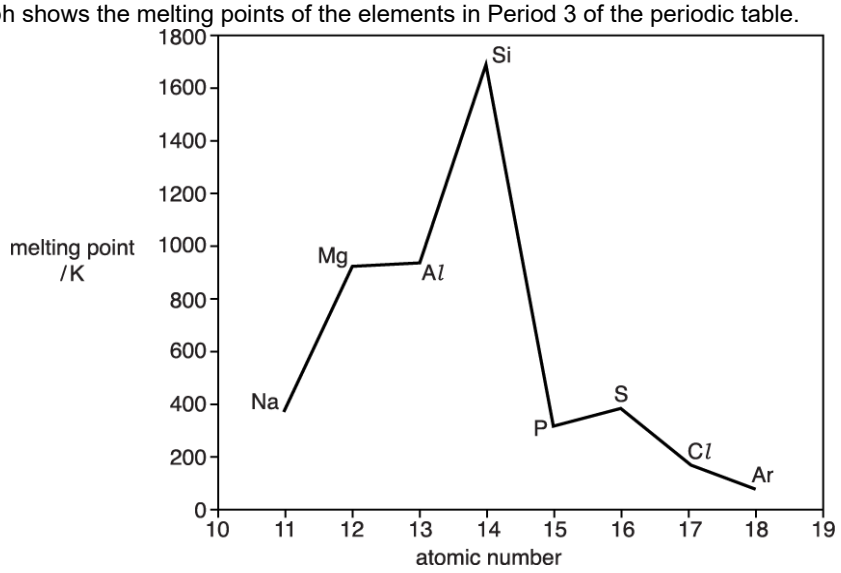
_____

_____ **[3]**

13(a). The graph shows the melting points of the elements in Period 3 of the periodic table.



Phosphorus and chlorine have simple molecular structures.
More information about phosphorus and chlorine is given in the table below.

Element	Molecular formula
phosphorus	P_4
chlorine	Cl_2

Explain the differences in the melting points of phosphorus and chlorine.

_____

_____

_____

_____

_____

_____

_____ **[3]**

(b). Magnesium and silicon have different types of giant structures.

Describe the bonding in magnesium and in silicon.

Include the names of the particles and describe the forces between the particles in the structures.

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[4]

14. The trend in the first and second ionisation energies of Group 2 elements can be linked to the increase in chemical reactivity down the group.

The first and second ionisation energies of calcium and strontium are given in the table.

Element	First ionisation energy / $kJmol^{-1}$	Second ionisation energy / $kJmol^{-1}$
Ca	590	1145
Sr	550	1064

i. Write an equation, including state symbols, to represent the **second** ionisation energy of strontium.

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[1]

ii. Explain why the first ionisation energy of strontium is less than the first ionisation energy of calcium.

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[3]

15. This question is about the attraction between particles.

State how and explain why the attraction between nuclei and outermost electrons in gaseous atoms varies across Period 3.

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[2]

16. Aluminium has 13 successive ionisation energies.

i. Write the equation for the **third** ionisation energy of aluminium.

Include state symbols.

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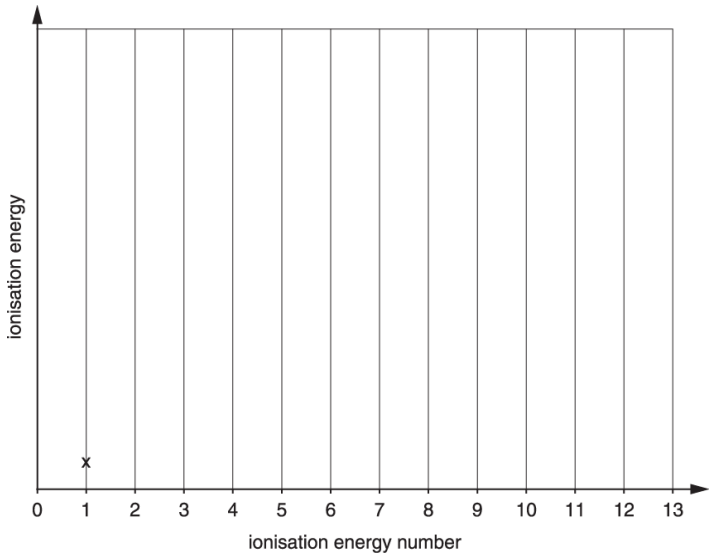
[1]

ii. On the axes below, add crosses to show the 13 successive ionisation energies of aluminium.

The value for the first ionisation energy has been completed for you.

You do not have to join the crosses.



[2]

17(a). Silicon dioxide, SiO_2, has the same structure and bonding as diamond.

State the structure and bonding in SiO_2.

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[1]

(b). Describe and explain the electrical conductivity of sodium oxide, Na_2O, and sodium in their solid and molten states.

In your answer you should use appropriate technical terms, spelled correctly.

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[5]

18. The Periodic Table is arranged in periods and groups.

Elements in the Periodic Table show a periodic trend in atomic radius.

State and explain the trend in atomic radius from Li to F.

In your answer you should use appropriate technical terms, spelled correctly.

trend

.....

explanation

.....

[3]

19. Give chemical explanations for the following statements.

Potassium is placed immediately after argon in the periodic table.

[1]

20. Bromine and mercury are the only two naturally occurring elements that are liquids at room temperature and pressure. Some physical properties of these two elements are given below.

	Appearance at room temperature	**Melting point / °C**	**Boiling point / °C**	**Electrical conductivity of the liquid**
Bromine	dark orange liquid	−7.2	58.8	very low
Mercury	shiny silver liquid	−38.8	356.7	good

Mercury and bromine react together to form mercury(II) bromide, $HgBr_2$.

Describe and explain how electrical conductivity occurs in mercury(II) bromide and mercury, in both solid and molten states.

[5]

21. * This question is about elements in Periods 3 – 4 of the periodic table.

The table shows the melting points of elements in Groups 14 – 17.

Phosphorus and sulfur exist as P_4 and S_8 molecules respectively.

	Group	**14**	**15**	**16**	**17**
Period 3	**Element** **Melting point / °C**	Si 1414	P 44	S 115	C*l* −102
Period 4	**Element** **Melting point / °C**	Ge 938	As 817	Se 221	Br −7

- Explain the trend in melting point from Si to C*l* across Period 3.
- Comment, with reasons, on the similarities and differences in the trends across Period 3 and Period 4.

Use the information in the table in your answer.

[6]

22(a). Ionisation energies can provide evidence for electron structure.
Write an equation for the first ionisation energy of chlorine.
Include state symbols.

_____ **[1]**

(b). The following data shows the first eight successive ionisation energies of an element.

Ionisation energy	1st	2nd	3rd	4th	5th	6th	7th	8th
Energy / kJ mol^{-1}	590	1145	4912	6474	8144	10 496	12 320	14 207

In which group of the periodic table would this element be found?

Use the data to justify your choice.

group:

_____

justification:

_____

_____

_____ **[2]**

23. Successive ionisation energies provide evidence for electron structure.

Sodium has eleven successive ionisation energies, shown in **Table 16.1**.

Ionisation number	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
Ionisation energy / kJ mol^{-1}	496	4562	6910	9543	13354	16613	20117	25496	28932	141362	159075

Table 16.1

i. Write the equation for the **seventh** ionisation energy of sodium.

Include state symbols.

[1]

ii. Why do successive ionisation energies increase with ionisation number?

[1]

iii. Explain how the successive ionisation energies in **Table 16.1** provide evidence for the electron shells in sodium atoms.

[2]

iv. The trend in first ionisation energies across periods gives further details of electron structure. The first ionisation energies of magnesium and aluminium are shown below.

Element	Mg	Al
First ionisation energy / kJ mol^{-1}	738	578

Explain how the first ionisation energies of magnesium and aluminium give further details of electron structure.

[2]

END OF QUESTION PAPER