Additional Assessment Materials

Summer 2021

Pearson Edexcel GCE in Chemistry 8CH0

Resource Set 1 – Topic Group 1

Topics included:

Topic 1: Atomic Structure and the Periodic Table

Topic 2: Bonding and Structure

(Public release version)

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

2 This question is about the structure of the atom and isotopes.

The following excerpt is taken from the book *Inorganic Chemistry* by Bailey and Snellgrove, fourth impression 1938.

> *"Some of the electrons are also contained in the nucleus, whilst the remainder are ..... arranged in rings revolving round the nucleus ..... The two isotopes [of chlorine] have therefore 18 and 20 electrons respectively in the nucleus and 17 [electrons] external to it."*

(a) Identify and correct **two** errors in the excerpt.

(2)

1. " some of the electrons are also contained in the nucleus". There are only protons and neutrons in the nucleus.
2. " the two isotopes of chlorine have 18 and 20 electrons". Both isotopes of chlorine have 17 electrons.

(b) What is the structure of a 1+ ion of the carbon-13 isotope?

(1)

- ☐ **A** six protons, six neutrons and five electrons
- ☐ **B** six protons, seven neutrons and six electrons
- ☒ **C** six protons, seven neutrons and five electrons
- ☐ **D** seven protons, six neutrons and six electrons

$^{13}_{6}C$

6 protons
5 electrons
7 neutrons

(c) (i) State what is meant by the term **relative atomic mass**.

(2)

weighted average mass of all isotopes of an element, relative to 1/12 the mass of an atom of carbon-12.

(ii) A 5.000 g sample of lithium, containing the two isotopes lithium-6 and lithium-7, was found to contain 0.460 g of the isotope lithium-6.

Calculate the relative atomic mass of lithium for this sample. Give your answer to an appropriate number of significant figures.

Isotope	Relative isotopic mass
Lithium-6	6.015
Lithium-7	7.016

(3)

RAM = % abundance x mass number

% Li-6 : $\frac{0.460}{5.000} \times 100 = 9.2\%$

% Li-7 : $\frac{5 - 0.46}{5.000} \times 100 = 90.8\%$

$$RAM = \frac{(9.2 \times 6.015) + (90.8 \times 7.016)}{100}$$

RAM = 6.92

(d) A mass spectrometer was used to analyse a sample of bromine, Br_2, with only the ^{79}Br and ^{81}Br isotopes present.

Explain why a very small peak occurs at $m/z = 80$.

(2)

A sample of Br_2 that contains ^{79}Br and ^{81}Br gives Br_2 a mass of 160. M/z 80 occurs due to the Br_2^{2+} ion;
160 ÷ 2 = 80

(Total for Question 2 = 10 marks)

(in a sample of bromine, the possible m/z values for the molecular ions are Br_2^+ = 158, 160 and 162. if one of these is doubly ionised, it will have an m/z value of 79, 80 and 81).

2 This question is about ionisation energies.

(a) (i) Which equation represents the **second** ionisation of bromine?

(1)

☐ **A** $Br(g) + e^- \rightarrow Br^-(g)$

☐ **B** $Br^-(g) + e^- \rightarrow Br^{2-}(g)$

☐ **C** $Br(g) - 2e^- \rightarrow Br^{2+}(g)$

☒ **D** $Br^+(g) - e^- \rightarrow Br^{2+}(g)$

(ii) Which set of successive ionisation energies is most likely to be associated with the element boron?

(1)

☐ **A** 738, 1 451, 7 733, 10 541, 13 629

☒ **B** 801, 2 427, 3 660, 25 026, 32 828

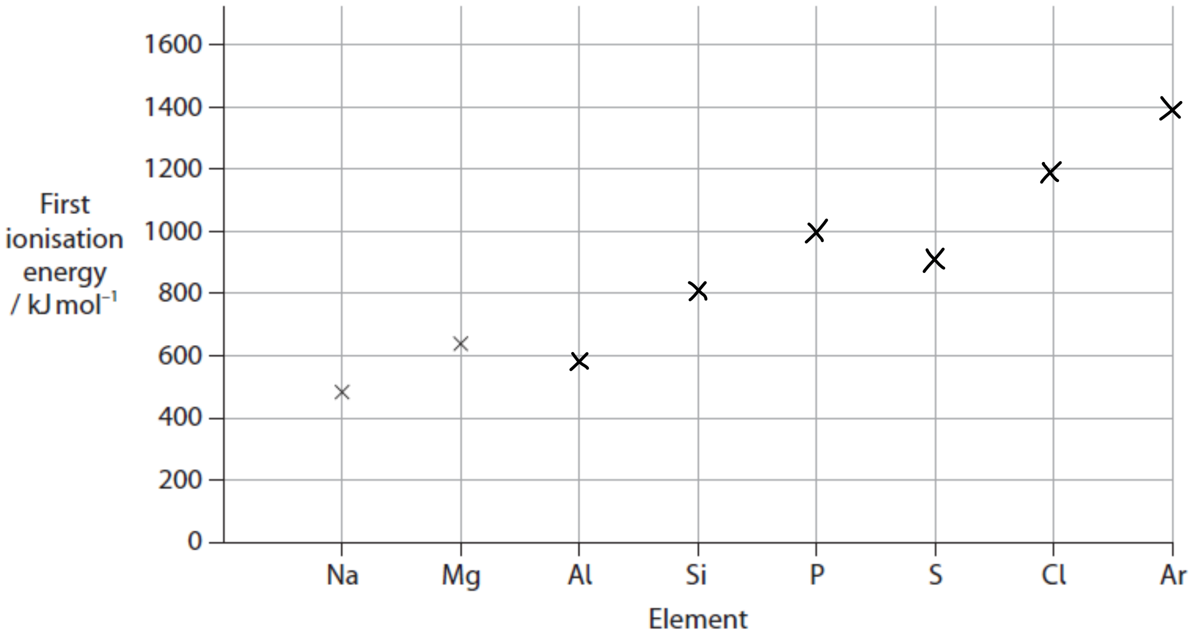
☐ **C** 1 086, 2 353, 4 621, 6 223, 37 832

☐ **D** 1 402, 2 856, 4 578, 7 475, 9 445

(b) (i) Complete the graph to show how the first ionisation energies of the Period 3 elements change across the period. Precise figures are not required.

(3)

First ionisation energies of the Period 3 elements



Mg (12) : $1s^2 2s^2 2p^6 3s^2$

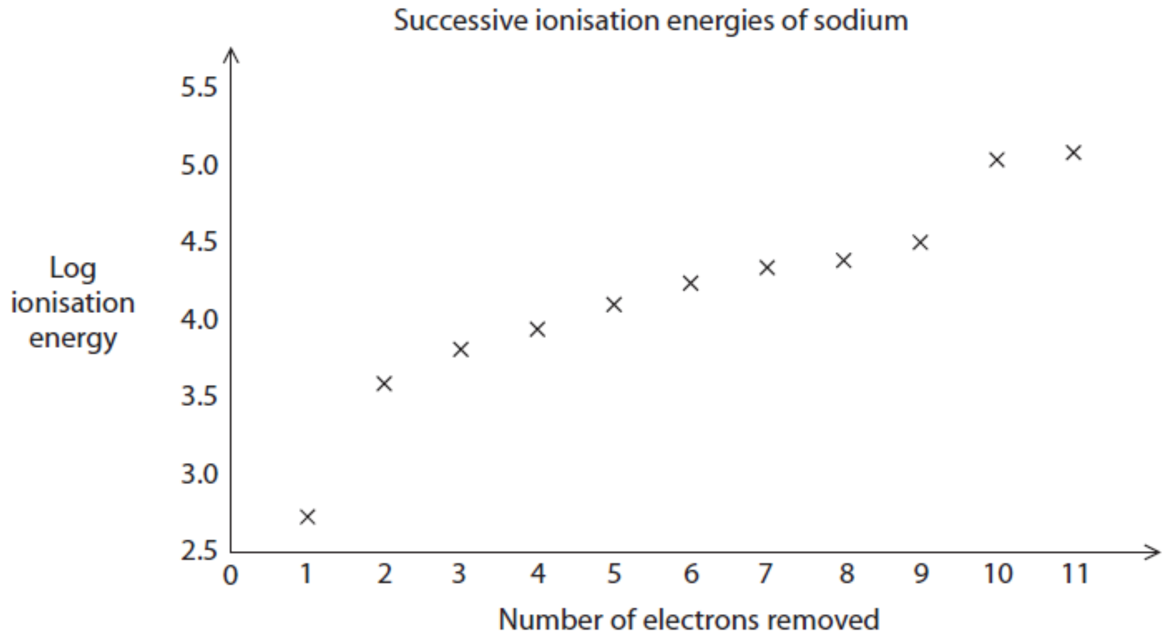
Al (13) : $1s^2 2s^2 2p^6 3s^2 3p^1$

Si (14) : $1s^2 2s^2 2p^6 3s^2 3p^2$

P (15) : $1s^2 2s^2 2p^6 3s^2 3p^3$

S (16) : $1s^2 2s^2 2p^6 3s^2 3p^4$

(ii) The successive ionisation energies of sodium are shown on the graph.



State what deductions can be made from this graph.

(2)

There are two big gaps between the first and second I.Es and ninth and tenth I.Es. This tells us that sodium has 3 shells (energy levels) The jump from 1 to 2 tells us that sodium has one electron in its outer shell, and 11 electrons in total.

(Total for Question 2 = 7 marks)

1 This question is about covalent bonds.

(a) State what is meant by the term covalent bond.

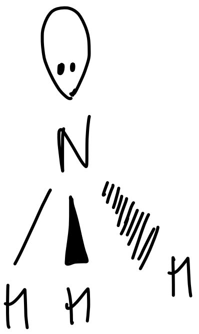
(2)

a shared pair of electrons - there is an electrostatic attraction between the electrons and the nucleus of the bonded atoms, holding the electrons between the two atoms.

(b) Draw a diagram of the ammonia molecule, clearly showing its shape.
Include any lone pairs of electrons and the value of the bond angle.

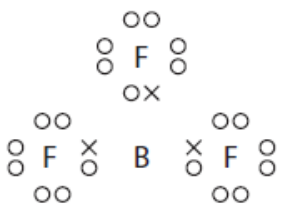
(2)

ammonia : NH_3



trigonal pyramidal
107°

(c) The dot-and-cross diagram of BF_3 is



What is the bond angle in BF_3?

(1)

☐ **A** 90°

☐ **B** 107°

☐ **C** 109.5°

☒ **D** 120°

(d) (i) Ammonia and boron trifluoride react to form a compound NH_3BF_3 which contains a dative covalent bond. Each of the molecules, NH_3 and BF_3, has a different feature of its electronic structure that allows this to happen.
Use these two different features to explain how a dative covalent bond is formed.

(2)

NH_3 has a lone pair of electrons on the nitrogen atom which is not being used in a bond. This lone pair can be donated to the boron in BF_3, which only has 6 electrons in its outer shell (3 bonding pairs with F).

(ii) During this reaction, the bond angles about the nitrogen atom and the boron atom change.

State the new H—N—H and F—B—F bond angles.

(2)

↓ 109.5°   ↓ 118°

(Total for Question 1 = 9 marks)

6 (a) The diagram shows bond angles in ammonia and water.

Explain why the bond angle in water is less than the bond angle in ammonia.

(2)

the oxygen atom in water has 2 lone pairs of electrons whereas the N atom in NH_3 only has 1 lone pair of electrons. Lone pairs repel more strongly than bonding pairs of electrons and so the bond angle is reduced from 107° to 104.5° (by 2.5° for each lone pair).

(b) Explain why the O—H and S—H bond lengths are different.

(3)

oxygen is smaller than sulfur as it has less electrons and ∴ holds them closer to the nucleus than sulfur. This makes oxygen more electronegative than sulfur and so pulls the shared pair of electrons towards itself more strongly than sulfur, making the bond shorter.

(Total for Question 6 = 5 marks)

8 The table shows some information about a selection of elements and compounds.

	Graphene	Graphite	Diamond	Magnesium oxide	Potassium bromide	Iron
Melting temperature / K	> 4000	3950	3820	3125	1007	1808
Density / $g\,cm^{-3}$	not measured	2.2 to 2.8	3.51	3.58	2.75	7.86
Compressive strength / GPa	not measured	2.3 and 15.3	443	152	15	170

(a) Explain the difference in the melting temperatures of magnesium oxide and potassium bromide. MgO and KBr

(3)

Both MgO and KBr are ionic compounds, but Mg^{2+} is smaller and more highly charged than K^+ and O^{2-} is smaller and more highly charged than Br^-. This means the attraction between Mg^{2+} and O^{2-} is stronger than between K^+ and Br^- so there's stronger ionic bonding in MgO than KBr, and more energy is required to break the ionic bonds in MgO.

(b) Explain why the electrical conductivity of solid potassium bromide is poor but an aqueous solution of potassium bromide is a good electrical conductor.

(2)

in solid potassium bromide the ions are not free to move as the lattice is fixed in shape, but in aqueous potassium bromide the ions are free to move and carry the electric current.

(d) Deduce **two** possible reasons why the density of iron (7.86 g cm^{-3}) is much greater than the density of graphite (2.2 to 2.8 g cm^{-3}).

(2)

iron atoms are heavier than carbon atoms, and iron has a greater compressive strength than graphite, meaning the atoms pack more closely together so more atoms of Fe can fit in a given volume. Iron has a 3D lattice structure whereas graphite is made up of sheets of hexagonal carbon atoms.

(e) The compressive strength is a measure of the energy required to break some of the bonds within a substance.

Deduce possible reasons why there are two widely different values for the compressive strength of graphite.
Both the values (2.3 and 15.3 GPa) are valid experimental results.

(2)

Graphite is made of layers of hexagonally-bonded carbon atoms, with van der Waal's forces between the layers. The compressive strength of the covalent bonds within the layers (between the carbon atoms) is much greater than that of the forces between the layers, which take much less energy to break.

(Total for Question 8 = 9 marks)

Total for Test – 40 marks