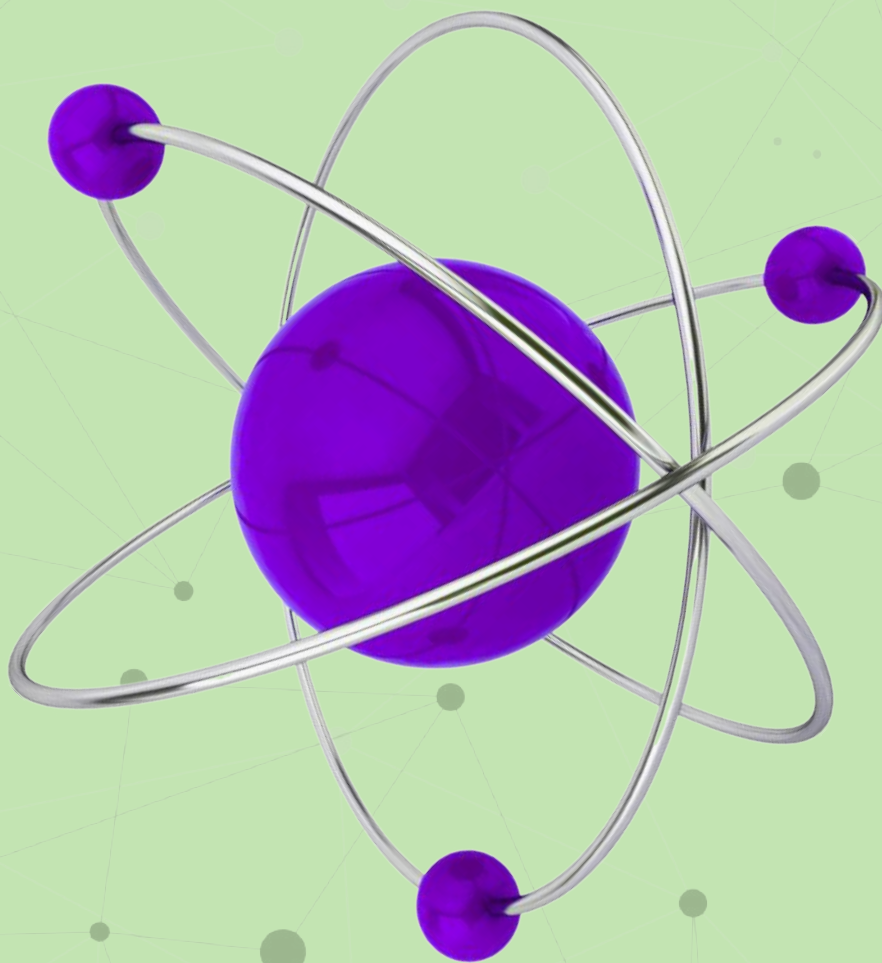


Cambridge IGCSE Chemistry



Classified Past Papers Paper 4

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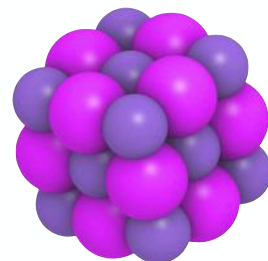
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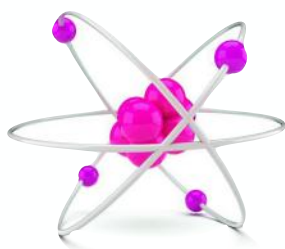
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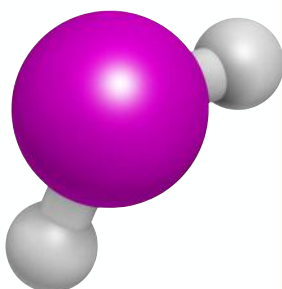
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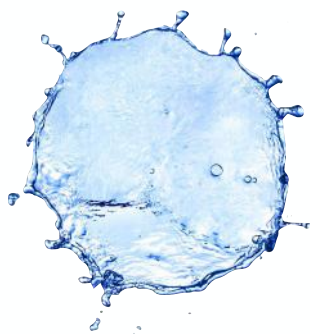
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Guiding words to write perfect answers

Define

Give a definition – use the definitions given in the IGCSE complete notes; or the definition list at the end of this book

Describe

You may have to describe a process or the appearance of a structure. When describing data in a table or a graph, use the words increase, decrease, constant, peak, maximum, minimum, etc.

Sketch

This is usually used about graphs. You should put a line (straight or curved) on a pair of axes. This may be a graph that has a line on it already or it may be pair of axes printed on the exam paper without a line or curve

Predict

This means you should state what you think will happen. You may be asked to justify your prediction or explain it; explanation is not required if all the question says is "predict..."

Calculate

This is obvious; make sure you know how to calculate percentages, percentage changes, rates and ratios (for genetics). Always give your working even if not asked and always make sure you use the correct units

State

Brief answer – maybe one word or a phrase

List

A number of brief answers should be given; usually you're asked for a specific number of points. You don't gain extra marks by writing more than the number stated

Explain

This is not the same as describe. You should give an answer that has some reasons. You may have to explain why something happens or how it happens

Estimate

You don't have to give an accurate answer – but your answer (which is usually numerical) should only be approximate

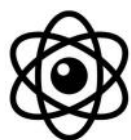
Measure

You should use a suitable measuring instrument to take a reading. Usually this involves using a ruler to measure to the nearest mm. Make sure you write down the unit after the numerical answer

Suggest

This is often used when there is no single correct answer; you should look through the information you have been given for some clues as to what to 'suggest' in response to the question. Many problem-solving questions use this command word

IGCSE



ATOMIC STRUCTURE



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EXPLANATION

1 A radioactive isotope of iodine, $^{131}_{53}\text{I}$, is used to treat cancer.

(i) Define the term *isotope*.

Atom with same number of protons but
different neutrons [2]

(ii) How many protons, electrons and neutrons are there in one atom of $^{131}_{53}\text{I}$?

number of protons 53
number of electrons 53
number of neutrons 78 [2]

(iii) When this isotope, $^{131}_{53}\text{I}$, emits radiation, a different element with a proton number of 54 is formed.

What is the name of this element?

Xe [1]

2 The table below gives the composition of six particles which are either atoms or ions.

particle	number of protons	number of neutrons	number of electrons
A	33	40	33
B	19	20	18
C	34	45	36
D	33	42	33
E	13	14	13
F	24	28	21

(a) Which particles are atoms? Explain your choice.

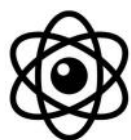
A - D - E [2]

(b) Which particle is a negative ion and why has this particle got a negative charge?

C, GAINED 2 ELECTRONS [2]

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ATOMIC STRUCTURE



(c) Which particles are positive ions?

B - F

[1]

(d) Explain why particle A and particle D are isotopes.

Same protons but different neutrons

[2]

[Total: 7]

3

In the Periodic Table, the elements are arranged in columns called Groups and in rows called Periods.

(a) (i) Complete the table for some of the elements in Period 3.

group number	I	II	III	IV	V	VI	VII
symbol	Na	Mg	Al	Si	P	S	Cl
number of valency electrons	1	2	3	4	5	6	7
valency	1	2	3	4	3	2	1

[2]

(ii) What is the relationship between the group number and the number of valency electrons?

group number = valency electrons

[1]

(iii) Explain the relationship between the number of valency electrons and the valency

for the elements Na to Al,

the valency is the same as the number of valency (outer) electrons because this is the number of electrons lost (for full energy level)

for the elements P to Cl.

the valency is 8 - [number of valency (outer) electrons]

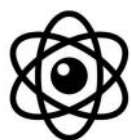
[4]



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ATOMIC STRUCTURE



4

$^{45}_{21}\text{Sc}$ represents an atom of scandium.

How many nucleons and how many charged particles are there in one atom of scandium?

number of nucleons 45

number of charged particles 42 (protons + electrons)

[2]



CLICK FOR
EXPLANATION

(c) Two different atoms of sodium are $^{23}_{11}\text{Na}$ and $^{24}_{11}\text{Na}$.

(i) Explain why these two atoms are isotopes.

same protons but different neutrons

[2]

(ii) $^{24}_{11}\text{Na}$ is radioactive. It changes into an atom of a different element which has one more proton.

Identify this element.

Mg [1]

5

The table gives the composition of three particles.

particle	number of protons	number of electrons	number of neutrons
A	15	15	16
B	15	18	16
C	15	15	17

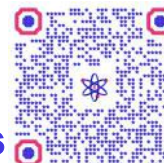
(a) What is the evidence in the table for each of the following?

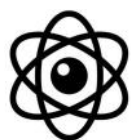
(i) Particle A is an atom.

same protons but different neutrons

[1]

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ATOMIC STRUCTURE



- (ii) **A, B** and **C** are all particles of the same element.

Same number of protons

[1]

- (iii) Particles **A** and **C** are isotopes of the same element.

same protons but different neutrons

[2]

- (b) (i) What is the electronic structure of particle **A**?

2, 5, 8

[1]

- (ii) Is element **A**, a metal or a non-metal? Give a reason for your choice.

[1]

[Total: 6]

- 6** The following are gallium atoms.



Complete the following table.

atom	number of protons	number of neutrons	number of electrons
${}_{31}^{69}\text{Ga}$	31	38	31
${}_{31}^{71}\text{Ga}$	31	40	31

[3]



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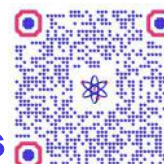
- 7** Protons, neutrons and electrons are subatomic particles.

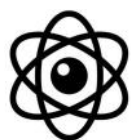
- (a) Complete the table to show the relative mass and relative charge of a proton, a neutron and an electron.

particle	relative mass	relative charge
proton	1	+1
neutron	1	0
electron	$\frac{1}{1840}$	-1

[3]

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ATOMIC STRUCTURE



(b) Bromine has two isotopes.

(i) Define the term *isotope*.

.....
same number of protons. They can have different
numbers of neutrons. [2]

(ii) Explain why the two isotopes of bromine have the same chemical properties.

.....
same number of outer shell / valence electrons
..... [2]

8

(a) (i) Define the term *atomic number*.

.....
Number of protons in the nucleus of the atom [1]

(ii) Define the term *nucleon number*.

.....
total number of protons and neutrons in the atom
which equal to the mass number of this atom [2]



CLICK FOR
EXPLANATION

(b) The table shows the number of protons, neutrons and electrons in some atoms or ions.

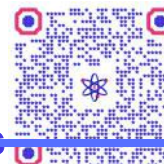
Complete the table. The first line is given as an example.

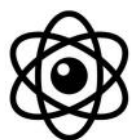
particle	number of protons	number of electrons	number of neutrons	symbol or formula
A	6	6	6	$^{12}_6\text{C}$
B	12	12	12	12-Mg-24
C	8	10	8	$^{16}_8\text{O}^{2-}$
D	11	10	13	11-Na+-24

[6]

[Total: 9]

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ATOMIC STRUCTURE



9 This question is about atoms, ions and isotopes.

(a) Define the term *nucleon number*.

The total number of protons and neutrons in the atom
is equal to the mass number of this atom. [2]

(b) Give the electronic structure of the following atom and ion.

Na 2,8,1

P³⁻ 2,8,8 [2]

(d) What is meant by the term *relative atomic mass*?

average mass of naturally occurring atoms of an element
compared to an atom of carbon-12 [2]

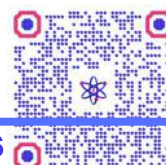
(e) Suggest why the relative atomic mass of chlorine is **not** a whole number.

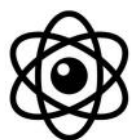
chlorine must have more than one isotope
the masses of these isotopes are averaged [2]



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ATOMIC STRUCTURE



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- 10** (a) Complete the table.

particle	charge	relative mass
proton	+1	1
neutron	0	1
electron	-1	close to 0

[2]

- (b) The following are isotopes of carbon.



- (i) In terms of numbers of protons, neutrons and electrons, how are these **three** isotopes the same and how are they different?

They are the same because **same protons and electrons**

.....

They are different because **different neutrons**

.....

[3]

- (ii) Why do all isotopes of carbon have the same chemical properties?

same number of valence electrons [1]

- (c) Name **two** forms of the element carbon which have giant covalent structures.

diamond and **graphite** [1]

- 11** This question is about subatomic particles.

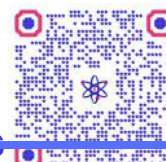
- (a) Define the terms

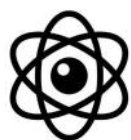
proton number, **number of protons in the nucleus of an atom**

.....

nucleon number, **The total number of protons and neutrons in the atom is equal to the mass number of this atom.** [3]

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ATOMIC STRUCTURE



- (b) Why is the ${}^1_1\text{H}$ hydrogen atom the **only** atom to have an identical proton number and nucleon number?

hydrogen is the only atom to have no neutrons

[1]

- 12** Carbon and silicon are elements in Group IV of the Periodic Table. Both carbon and silicon exist as more than one isotope.

- (a) Define the term *isotopes*.

Atoms of the same element with same protons but different neutrons

[2]

- (b) Complete the following table which gives information about carbon atoms and silicon atoms.

	carbon	silicon
proton number	6	14
electronic structure	2, 4	2, 8, 4
nucleon number	12	28
number of neutrons in one atom	6	14

[3]



CLICK FOR EXPLANATION

- 13** Six different atoms can be represented as follows.



- (a) Answer the following questions using atoms from the list. Each atom may be used once, more than once or not at all.

Select **one** atom from the six shown which

- (i) has exactly seven protons,

J

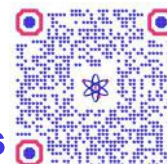
[1]

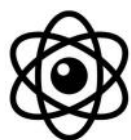
- (ii) has exactly six neutrons,

E

[1]

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ATOMIC STRUCTURE



- (iii) has more protons than neutrons,

D

..... [1]

- (iv) has the electronic structure [2,5],

J

..... [1]

- (v) is an atom of an element from Group VII of the Periodic Table,

L

..... [1]

- (vi) is an atom of a noble gas.

D

..... [1]

- (b) Two of the six atoms shown are isotopes of each other.

- (i) What is meant by the term *isotopes*?

Atoms of the same element with same protons but
different neutrons

..... [2]

- (ii) Which **two** of the six atoms shown are isotopes of each other?

E & G

..... [1]

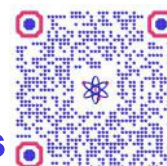
- (iii) Why do isotopes have identical chemical properties?

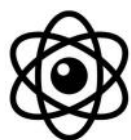
Same number of valence electrons

..... [1]

[Total: 10]

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ATOMIC STRUCTURE



14

The table gives information about five particles. The particles are all atoms or ions.

particle	number of protons	number of neutrons	number of electrons
A	6	8	6
B	12	12	12
C	13	14	10
D	8	8	10
E	11	12	11



CLICK FOR
EXPLANATION

Answer the following questions using the information in the table.
Each particle may be used once, more than once or not at all.

(a) Which particle, **A**, **B**, **C**, **D** or **E**,

(i) is an atom with atomic number 12,

B

[1]

(ii) is an atom with nucleon number 14,

A

[1]

(iii) is an ion with a positive charge,

C

[1]

(iv) has only **one** electron in its outer shell?

E

[1]

(b) **D** is an ion of an element.

Identify the element and write the formula of **D**.

Oxygen O²⁻

[2]

[Total: 6]

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ATOMIC STRUCTURE



15

Flerovium, Fl, atomic number 114, was first made in research laboratories in 1998.

- (a) Flerovium was made by bombarding atoms of plutonium, Pu, atomic number 94, with atoms of element Z.

- The nucleus of **one** atom of plutonium combined with the nucleus of **one** atom of element Z.
- This formed the nucleus of **one** atom of flerovium.

Suggest the identity of element Z.

Calcium ($114 - 94 = 20$, which is the atomic number of Ca) [1]

- (b) In which period of the Periodic Table is flerovium?

..... 7 [1]

- (c) Predict the number of outer shell electrons in an atom of flerovium.

..... 7 [1]

- (ii) Complete the table to show the number of protons, neutrons and electrons in the atoms of the isotopes shown.

isotope	number of protons	number of neutrons	number of electrons
^{286}Fl	114	172	114
^{289}Fl	114	175	114

[2]

16

- (a) The table gives information about some atoms or ions, A, B and C.

Complete the table.

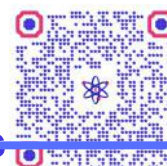
	number of protons	number of electrons	electronic structure	charge
A	11	10	2,8	1+
B	18	18	2,8,8	0
C	9	10	2,8	-1

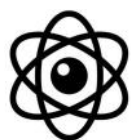
[4]



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ATOMIC STRUCTURE



- (b) (i) Carbon is an element.

Define the term *element*.

A substance made of atoms with the same atomic number [1]

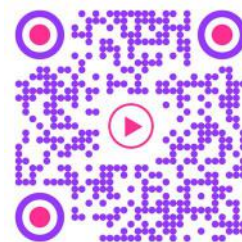
- (ii) $^{12}_6\text{C}$, $^{13}_6\text{C}$ and $^{14}_6\text{C}$ are isotopes of carbon.

Complete the table.

	number of protons	number of neutrons
$^{12}_6\text{C}$	6	6
$^{13}_6\text{C}$	6	7
$^{14}_6\text{C}$	6	8

[2]

[Total: 7]



**CLICK FOR
EXPLANATION**

17

The Periodic Table is very useful to chemists.

Refer only to elements with atomic numbers 1 to 36 in the Periodic Table provided when answering **Question 1**.

- (a) Use information from the Periodic Table provided to identify **one** element which:

- (i) has atoms with exactly 9 protons **fluorine** [1]
 (ii) has atoms with 0 neutrons **hydrogen** [1]
 (iii) has atoms with exactly 23 electrons **vanadium** [1]
 (iv) has atoms with an electronic structure of 2,8,6 **sulfur** [1]
 (v) forms ions with a charge of 3– containing 18 electrons **phosphorus** [1]
 (vi) forms ions with a charge of 2+ containing 10 electrons **magnesium** [1]
 (vii) has a relative atomic mass that shows it has at least two isotopes. **chlorine** [1]

- (b) State which metal in the first 36 elements:

- (i) is the Group I element which reacts most vigorously with water **potassium** [1]

[Total: 9]

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Where marks are lost

Drawing a double or triple bond between the chlorines. Cl_2 has just ONE shared pair; the remaining electrons are lone pairs. Draw them in pairs.

Examiner's insight

Answered very well; multiple bonds were drawn very occasionally.

● 3 (f)(i)

Deduce · [2 marks]

The melting point of chlorine is -101°C and its boiling point is -35°C . Deduce the physical state of chlorine at -75°C and use the data to explain your answer.

Model answer

✓ Chlorine is a liquid at -75°C . ✓ -75°C is above the melting point (-101°C) but below the boiling point (-35°C), so chlorine has melted but not yet boiled – it is liquid.

Mark scheme 2 marks

- ✓ liquid (1)
- ✓ -75°C is above the melting point (-101) AND below the boiling point (-35) (1)

Where marks are lost

For the explanation mark you must refer to BOTH temperatures – the melting point and the boiling point – and handle the negative numbers correctly (-75 is higher than -101 , lower than -35). Naming just one temperature is not enough.

Examiner's insight

Many gave liquid correctly, but few referred to all three temperatures; candidates often quoted only the melting point or only the boiling point and struggled with negative numbers.

● 3 (f)(ii)

Explain · [3 marks]

Explain, in terms of structure and bonding, why potassium chloride has a much higher melting point than chlorine. Refer to the types of particle, the types of force between them and the relative strength of those forces.

Model answer

✓ In potassium chloride the particles are ions, held together by strong ionic bonds (strong **electrostatic** attraction between oppositely charged ions). ✓ In chlorine the particles are molecules, held together only by weak forces of attraction between the molecules (**intermolecular forces**). ✓ The attraction between chlorine molecules is much weaker than the ionic bonding in potassium chloride, so far less energy is needed to melt chlorine – hence its much lower melting point.

Where marks are lost

The frequent slip is leaving OFF the fluorine lone pairs - each F needs 6 non-bonding crosses so its octet is complete.

Examiner's insight

Many perfect answers; the usual error was omitting the non-bonding electrons on the fluorine atoms.

5 (c)

Explain · [3 marks]

Lithium nitride melts at 813 degrees C; nitrogen trifluoride melts at -206 degrees C.

Explain in terms of attractive forces why lithium nitride has a much higher melting point than nitrogen trifluoride. Refer to the types of force and their relative strengths.

Model answer

✓ Lithium nitride is ionic: there is strong attraction between the oppositely charged ions (strong ionic bonds throughout the **lattice**). ✓ Nitrogen trifluoride is a simple molecule: the attractions are between the molecules (weak **intermolecular forces**). ✓ The attraction between the ions is much stronger than the attraction between the NF_3 molecules, so far more energy is needed to melt lithium nitride.

Mark scheme 3 marks

- ✓ ionic bonds / attraction between ions in Li_3N (1)
- ✓ attraction between molecules in NF_3 (1)
- ✓ attraction in NF_3 is weaker (ORA) (1)

Where marks are lost

Do not contradict yourself: Li_3N is IONIC (ions), NF_3 is MOLECULAR (weak forces between molecules). Calling Li_3N molecular after saying ionic cancels the mark.

Examiner's insight

Many contradicted themselves, describing the ionic solid as molecular; the three points are ions in Li_3N , molecules in NF_3 , and the ionic attraction being stronger.

5 (d)(i)

Calculate · [2 marks]

Calculate the percentage by mass of nitrogen in ammonium nitrate, NH_4NO_3 .

Working

- ✓ **relative formula mass** of $\text{NH}_4\text{NO}_3 = (2 \times 14) + (4 \times 1) + (3 \times 16) = 80$
- ✓ **mass of N** = $2 \times 14 = 28$, so **% N** = $100 \times 28 / 80 = 35\%$

percentage by mass of nitrogen = 35%

Mark scheme 2 marks

- ✓ rfm of $\text{NH}_4\text{NO}_3 = 80$ (1)

knowledge of structure and bonding to explain why lead(II) oxide has a much higher melting point than carbon dioxide, referring to the particles involved and the relative strength of the forces between them.

Model answer

✓ Lead(II) oxide is ionic – it is a giant **lattice** of ions held together by strong ionic bonds (strong attraction between the ions). ✓ Carbon dioxide is made of small molecules, and the forces of attraction BETWEEN the molecules (**intermolecular forces**) are what must be overcome on melting. ✓ These **intermolecular forces** in carbon dioxide are much weaker than the ionic bonds in lead(II) oxide, so far less energy is needed to melt it (or the reverse argument).

Mark scheme 3 marks

- ✓ bonds between ions / ionic bonds in lead(II) oxide (1)
- ✓ attraction between molecules in carbon dioxide (1)
- ✓ weaker attraction between particles in carbon dioxide (ORA) (1)

Where marks are lost

Keep the two structures straight: PbO has ions and ionic bonds; CO₂ has molecules with weak forces BETWEEN them. Never say 'covalent bonds are weak' - it is the intermolecular forces that are weak, not the covalent bonds inside the molecule.

Examiner's insight

Poorly answered; candidates who said lead(II) oxide was ionic often contradicted it, many wrongly stated covalent bonds are weak, and few referred to forces between carbon dioxide molecules.

● 3 (g)

Write · [2 marks]

Aqueous lead(II) nitrate contains Pb²⁺ ions. Magnesium is more reactive than lead; copper is less reactive. Write an ionic equation for any reaction in Experiment 1 (magnesium added) and Experiment 2 (copper added); write 'no reaction' if none occurs.

Model answer

✓ Experiment 1: $\text{Mg} + \text{Pb}^{2+} \longrightarrow \text{Mg}^{2+} + \text{Pb}$ – magnesium is above lead, so it displaces lead from solution (magnesium is **oxidised**, lead(II) reduced). ✓ Experiment 2: no reaction – copper is below lead in the **reactivity series**, so it cannot displace lead.

Mark scheme 2 marks

- ✓ $\text{Mg} + \text{Pb}^{2+} \longrightarrow \text{Mg}^{2+} + \text{Pb}$ (1)
- ✓ no reaction (copper) (1)

Cambridge IGCSE Chemistry - Solved Past Paper

October/November 2022 · Paper 4 (0620/41) · Question 2 · Bonding and salt preparation

● hard ● medium ● easy

● 2 (a)

Describe · [4 marks]

Potassium is a Group I element. Name and describe the bonding in potassium.

Model answer

✓ The bonding is metallic. ✓ A regular **lattice** of positive potassium ions ✓ sits in a 'sea' of **delocalised electrons** that are free to move. ✓ There is a strong **electrostatic** attraction between the positive potassium ions and the **delocalised electrons**, and this holds the metal together.

Mark scheme 4 marks

- ✓ metallic (1)
- ✓ lattice of potassium ions (1)
- ✓ sea of (delocalised) electrons (1)
- ✓ attraction between the potassium ions and the electrons (1)

Where marks are lost

Describing IONIC bonding by mistake, saying 'free' electrons instead of mobile/delocalised, or forgetting the ATTRACTION between the positive ions and the electrons. All four ideas - metallic, lattice of ions, sea of electrons, attraction - are needed.

Examiner's insight

Found challenging; many described ionic bonding, used 'free' rather than mobile electrons, or omitted the lattice of positive ions and the attraction between the charges.

● 2 (b)(i)

Give · [2 marks]

Potassium sulfide, K_2S , is an ionic compound. Give two physical properties of ionic compounds.

Model answer - any two

✓ High **melting point** and **boiling point**. ✓ Conducts electricity when molten or in aqueous solution (but not when solid). Also accepted: **soluble** in water.

Mark scheme any two - 2 marks

- ✓ high melting point / boiling point (1)
- ✓ conducts electricity when molten or aqueous (1)
- ✓ soluble in water (1)

Cambridge IGCSE Chemistry · Solved Past Paper

May/June 2024 · Paper 4 (0971/41) · Question 2 · Atomic structure - protons, electrons, neutrons

● hard ● medium ● easy

● 2

Complete · [5 marks]

Complete Table 2.1 for the atom or ion in each row (protons, electrons and neutrons, and the missing symbol).

Completed Table 2.1

atom or ion	number of protons	number of electrons	number of neutrons
$^{37}_{17}\text{Cl}$	17	17	20
$^{63}_{29}\text{Cu}^+$	29	28	34
$^{33}_{16}\text{S}^{2-}$	16	18	17

How the five marks fall

✓ $^{37}_{17}\text{Cl}$: proton number = 17 (from the symbol), and neutrons = mass - protons = $37 - 17 = 20$. ✓ $^{63}_{29}\text{Cu}^+$: protons = 29, and a 1+ ion has one electron fewer than protons, so $29 - 1 = 28$ electrons. ✓ The missing ion has mass number 33 (above) and proton number 16 (below) written on the left of the symbol. ✓ 16 protons means the element is sulfur, S. ✓ 18 electrons on 16 protons is two extra negatives, so the charge is 2-, giving $^{33}_{16}\text{S}^{2-}$.

Mark scheme 5 marks

- ✓ Cl: 17 protons AND 20 neutrons (1)
- ✓ Cu^+ : 29 protons AND 28 electrons (1)
- ✓ 33 (above) and 16 (below) on the left of the symbol (1)
- ✓ element is S (1)
- ✓ charge is 2- (1)

Where marks are lost

Giving sulfur's mass number as 32 (from the Periodic Table) instead of 33 = $16 + 17$ from THIS ion's data. And the charge was often missing or written as just a minus rather than 2-.

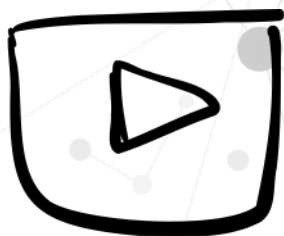
Examiner's insight

Answered well by most; the frequent slips were a mass number of 32 for sulfur and a missing or wrong charge (given as -).

Revise from your notes

- Protons, neutrons and electrons; isotopes and ions

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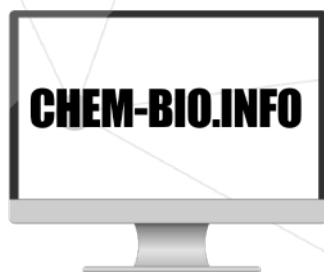
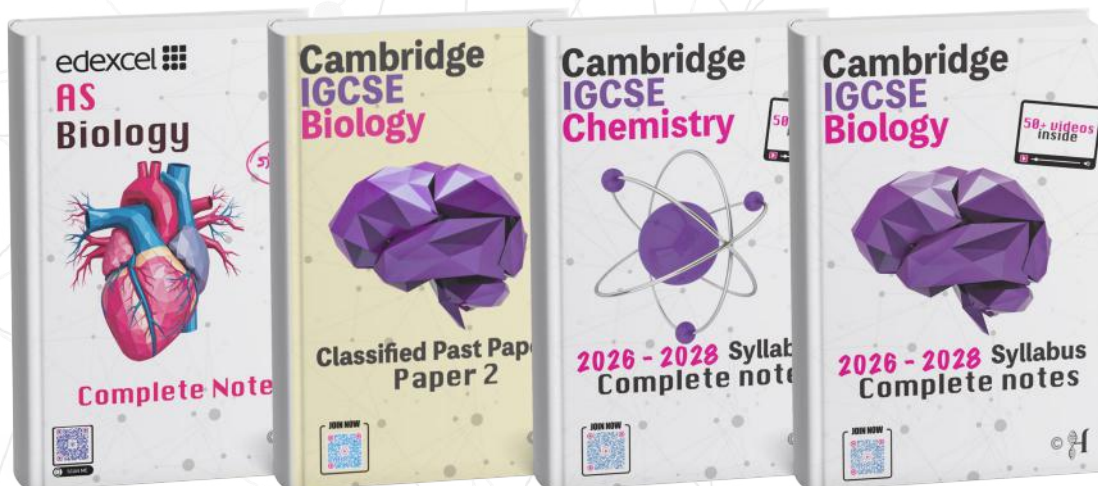


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