

(ii) the element with the highest first ionisation energy, [1]

May/June 2017 9701/21 · Q3 (a)(ii)

(a) Complete the table.

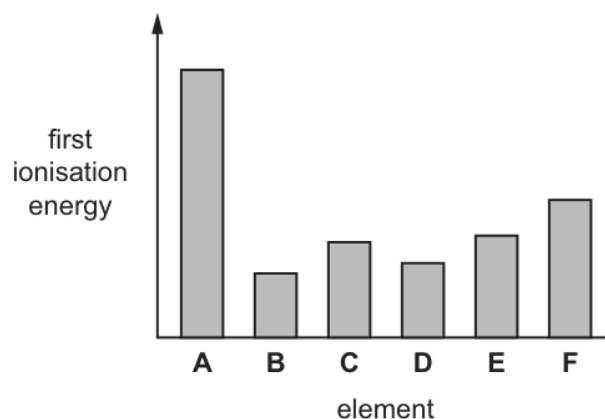
atomic number	nucleon number	number of electrons	number of protons	number of neutrons	symbol
3		2			${}^6_3\text{Li}^+$
		23	26	32	

[2]

May/June 2017 9701/22 · Q1 (a)

- 1 (a) The graph shows a sketch of the first ionisation energies of six successive elements in the Periodic Table.

The letters are **not** the symbols of the elements.



- (i) Explain what is meant by the term *first ionisation energy*.

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.....

.....

..... [3]

- (ii) Suggest why the first ionisation energy of **B** is much less than that of **A**.

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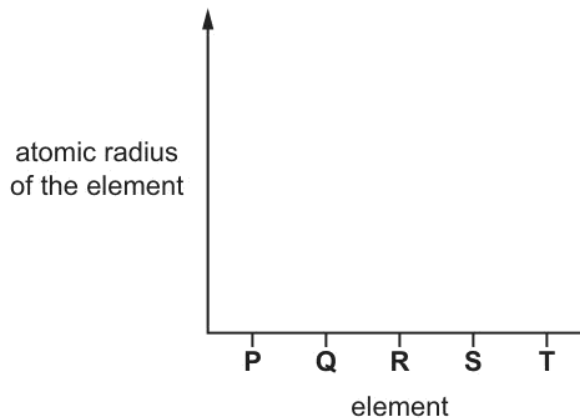
..... [3]

(b) P–T are successive elements in Period 3 of the Periodic Table.

The letters are **not** the symbols of the elements.

On the axes, sketch a graph to show the trend in the atomic radius of the elements P–T.

Explain your answer.



explanation

.....

.....

.....

.....

[3]

[Total: 9]

March 2018 9701/22 · Q1 (a)(i), (a)(ii), (b) (cont.)

- (ii) When silicon reacts with magnesium, Mg_2Si forms. Mg_2Si is thought to contain the Si^{4-} ion.

State the full electronic configuration of the Si^{4-} ion.

$1s^2$ [1]

March 2018 9701/22 · Q2 (d)(ii)

- (b) The first ionisation energies of the elements across the third period show a general increase. Aluminium and sulfur do **not** follow this general trend.

- (i) Explain why aluminium has a lower first ionisation energy than magnesium.

.....
.....
..... [2]

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- (ii) Explain why sulfur has a lower first ionisation energy than phosphorus.

.....
.....
..... [2]

May/June 2018 9701/21 · Q3 (b)(i), (b)(ii)

- (b) (i) Complete the electronic configuration of a chloride ion.

$1s^2$ [1]

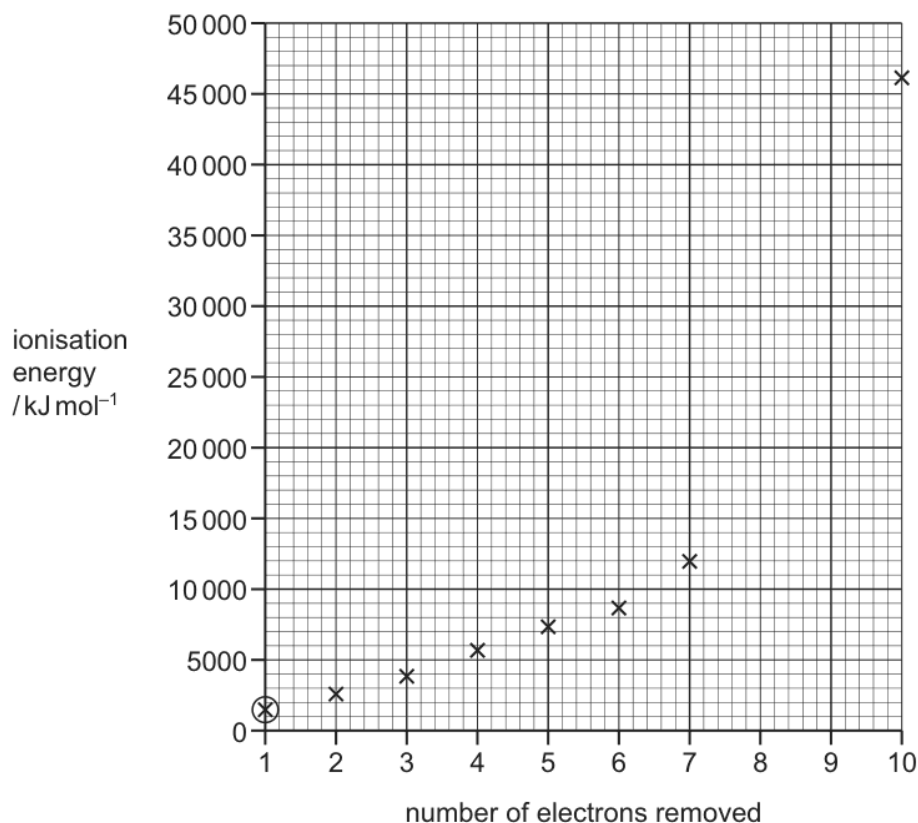
March 2019 9701/22 · Q2 (b)(i)

- 3 (a) Construct an equation for the **second** ionisation energy of argon.

..... [1]

- (b) The graph shows successive ionisation energies for the element argon.

Complete the graph with predictions for the eighth and ninth ionisation energies of argon.
Use a cross (x) for each data point. [2]



- (c) The energy value required to remove the first electron from an atom of argon is circled on the graph.

Sketch the shape of the orbital that contains this electron.

[1]

7

- (ii) Calculate the number of chlorine atoms in this sample of $\text{Cl}_2(\text{g})$. You may find it helpful to use your answer to (d)(i).

If you are unable to calculate an answer to (d)(i), use 0.36 g of Cl_2 . This is **not** the correct answer.

number of chlorine atoms = [2]

May/June 2019 9701/21 · Q3 (a), (b), (c), (d)(ii) (cont.)

- (c) The electronic configuration of a sulfur atom is $1s^2 2s^2 2p^6 3s^2 3p^4$.

- (i) Identify which orbital in a sulfur atom has the lowest energy.

..... [1]

- (ii) Sketch the shape of a p orbital.

[1]

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

.....
.....
.....
..... [2]

[Total: 12]

4

(a) Elements in the p block show a general increase in first ionisation energy as the atomic number increases.

(i) Draw the shape of a p orbital.

[1]

(ii) Write an equation to show the first ionisation energy of silicon.

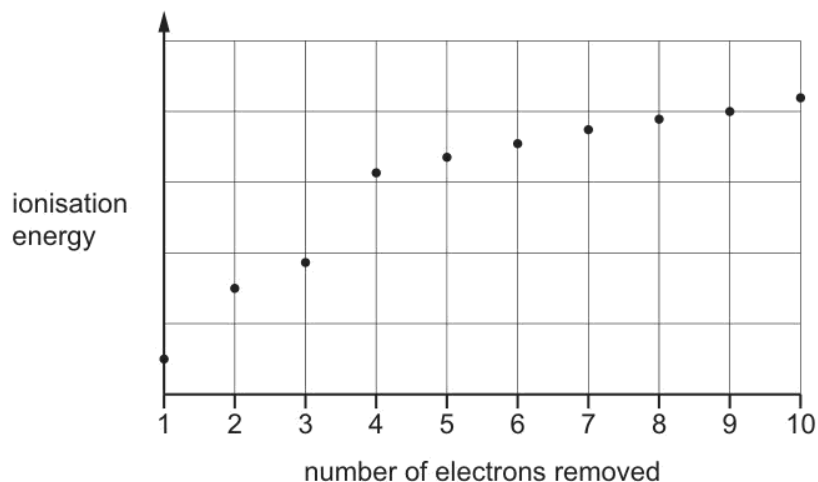
..... [1]

(iii) Explain why there is a general increase in first ionisation energies of the elements across Period 3.

.....
.....
.....
..... [2]

(iv) Element **A** is in the p block.

The graph shows the successive ionisation energies for the removal of the first ten electrons of **A**.



State and explain the group of the Periodic Table that element **A** belongs to.

group number

explanation

.....

.....

[2]

- (b) Silicon is found in many compounds in the Earth's crust. Silicon has only three naturally occurring isotopes, ^{28}Si , ^{29}Si and ^{30}Si .

- (i) The table shows data for ^{28}Si , ^{29}Si and ^{30}Si .

	^{28}Si	^{29}Si	^{30}Si
relative isotopic mass	28.0	29.0	30.0

A sample of silicon contains 92.2% ^{28}Si . The total percentage abundance of ^{29}Si and ^{30}Si in the sample is 7.8%.

The relative atomic mass, A_r , of silicon in the sample is 28.09.

Calculate the percentage abundance of ^{30}Si .

Give your answer to **one** decimal place.

percentage abundance of ^{30}Si = %
[3]

- (ii) Silicon reacts with nitrogen gas to form Si_3N_4 .

Si_3N_4 is a solid with a melting point of 1900 °C. It is insoluble in water and does not conduct electricity when molten.

Suggest the type of bonding in **and** structure of Si_3N_4 . Explain your answer.

.....

 [3]

- (c) Sulfur-containing compounds, such as $\text{C}_2\text{H}_5\text{SH}$, are found in fossil fuels, and produce SO_2 when they are burned.

- (i) Write the equation to show the complete combustion of $\text{C}_2\text{H}_5\text{SH}$.

..... [1]

- (ii) State why the presence of SO_2 in the atmosphere has environmental consequences. Describe **one** of the consequences on the environment.

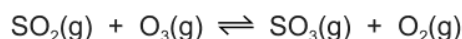
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..... [2]

- (d) SO_2 can react with ozone, O_3 , to form SO_3 in two different reactions.

- (i) In one reaction, SO_2 reacts with O_3 until a dynamic equilibrium is established.



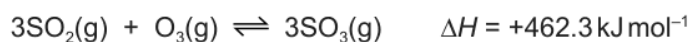
State and explain the effect of an increase in pressure on the composition of the equilibrium mixture.

.....

.....

..... [2]

- (ii) In the other reaction, a different equilibrium is established at 300 K as shown.



Suggest a temperature needed to increase the yield of SO_3 at equilibrium.

Explain your answer.

.....

.....

..... [2]

[Total: 19]

6

Oct/Nov 2019 9701/22 · Q1 (a)(i), (a)(ii), (a)(iii), (a)(iv), (b)(i), (b)(ii), (c)(i), (c)(ii), (d)(i), (d)(ii) (cont.)

(a) There are two stable isotopes of gallium, ^{69}Ga and ^{71}Ga .

(i) State, with reference to subatomic particles, how the isotopes ^{69}Ga and ^{71}Ga differ from each other.

.....
..... [1]

(b) Gallium and its compounds show similar properties to aluminium and its compounds. Gallium reacts with excess chlorine to form gallium trichloride.

(i) At 500°C , gallium trichloride is a gas.

Suggest the type of attraction that exists at 500°C

- between atoms within a gallium trichloride molecule

.....

- between gallium trichloride molecules.

..... [2]

(ii) When gallium trichloride is cooled a solid, Ga_2Cl_6 , forms.

Suggest the name of the attraction formed between two gallium trichloride molecules to form Ga_2Cl_6 .

..... [1]

(c) Gallium metal reacts rapidly when exposed to air. A white solid layer is formed on its surface.

(i) Suggest an equation to describe the reaction occurring when gallium metal is exposed to air.

..... [2]

(c) Complete the table which describes a gaseous atom of gallium.

isotope	nucleon number	total number of electrons in lowest energy level	type of orbital which contains the electron in the highest energy level
^{71}Ga			

[3]

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May/June 2020 9701/22 · Q1 (c)

(iii) State the electronic configuration of a copper atom.

$1s^2$ [1]

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May/June 2020 9701/23 · Q2 (c)(iii)

- (a) Write an equation for the first ionisation energy of Mg.

Include state symbols.

..... [1]

- (b) Explain the observed trend in first ionisation energies down Group 2.

.....
.....
.....
.....
.....
..... [3]

- (c) The second ionisation energy of Be is 1757 kJ mol^{-1} .

Explain why the second ionisation energy of Be is higher than the first ionisation energy of Be.

.....
.....
.....
.....
..... [2]

[Total: 6]

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Oct/Nov 2020 9701/21 · Q1 (a), (b), (c)

- (iii) Lithium hydride contains the ions Li^+ and H^- .

State the electronic configuration of these two ions.

Li^+ H^- [1]

Oct/Nov 2020 9701/21 · Q3 (a)(iii)

(b) Electrons in atoms up to $_{36}\text{Kr}$ are distributed in s, p and d orbitals.

(i) State the number of occupied orbitals in an isolated atom of $_{36}\text{Kr}$.

type of orbital	s	p	d
number of orbitals			

[3]

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(iii) The diagram shows a type of orbital.



State the total number of electrons that exist in all orbitals of this type in an atom of $_9\text{F}$.

..... [1]

(iv) The first ionisation energies of elements in the first row of the d block ($_{21}\text{Sc}$ to $_{29}\text{Cu}$) are very similar. For all these elements, it is a 4s electron that is lost during the first ionisation.

Suggest why the first ionisation energies of these elements are very similar.

.....

 [3]

Oct/Nov 2020 9701/22 · Q1 (b)(i), (b)(iii), (b)(iv)

(b) Chlorine has the highest first ionisation energy of the Period 3 elements Na to Cl.

(i) Construct an equation for the first ionisation energy of chlorine.

Include state symbols.

..... [1]

(ii) Explain the general increase in the first ionisation energies of the Period 3 elements.

.....
.....
.....
..... [2]

(iii) Give the electronic configuration of Cl^* .

$1s^2$ [1]

(c) In reaction 4, calcium carbide, CaC_2 , is formed from CaO .

CaC_2 contains the C_2^{2-} anion. Each carbon in C_2^{2-} is sp hybridised.

(i) Describe how sp hybridised orbitals are formed.

.....
..... [1]

(ii) Sketch a diagram to show how two sp hybrid orbitals can form a sigma (σ) bond.

[2]

Oct/Nov 2021 9701/21 · Q2 (c)(i), (c)(ii)

- 2 (a) Table 1 gives physical data for some of the Period 3 elements.

Table 1

atomic number, Z	11	12	13	14	15	16	17
bonding present in element	M						C
first ionisation energy / kJ mol ⁻¹	494	736	577	786	1060	1000	1260
maximum oxidation number							+7
anionic radius / nm	–	–	–	0.271	0.212	0.184	0.181

- (i) Complete the row in the table labelled 'bonding present in element'.

Use C = covalent, I = ionic, M = metallic, as appropriate.

[1]

- (ii) Explain the difference between the first ionisation energies of the elements with atomic numbers 11 and 17.

.....

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.....

..... [2]

- (iii) Explain the difference between the first ionisation energies of the elements with atomic numbers 15 and 16.

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..... [2]

- (v) Explain the variation in anionic radius for the elements with atomic numbers 14 to 17.

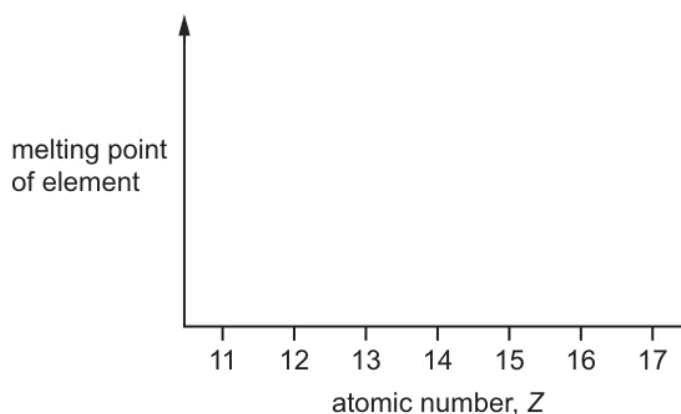
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..... [2]

- (b) Use the axes to sketch a graph that shows the trend in melting points of the elements with atomic numbers 11 to 17.



[2]

- (c) Dmitri Mendeleev published the first Periodic Table in 1869.

Mendeleev used his knowledge of chemical periodicity to propose the properties of gallium, $_{31}\text{Ga}$, a Group 13 element.

Table 2 gives some chemical and physical data of elements in Group 13.

Table 2

element	density / g cm^{-3}	boiling point /K	cationic radius /nm
$_{5}\text{B}$	2.34	3930	0.020
$_{13}\text{Al}$		2470	0.050
$_{31}\text{Ga}$	5.91	2400	
$_{49}\text{In}$	7.30		0.081
$_{81}\text{Tl}$	11.8	1460	0.095

Complete the table by predicting values for the missing data.

[3]

(d) Indium and aluminium are elements in Group 13 of the Periodic Table.

Indium has very similar chemical properties to aluminium.

- Indium reacts vigorously with hydrochloric acid to form a colourless gas and a salt in solution.
- Indium oxide, In_2O_3 , is amphoteric.
- Gaseous indium bromide has the formula In_2Br_6 . This molecule contains coordinate bonds.

(i) Identify the formula of the salt formed when indium reacts with hydrochloric acid.

..... [1]

(ii) Construct an equation for the reaction of In_2O_3 with excess aqueous NaOH .

..... [1]

(iii) Draw a diagram that clearly shows the types of bond present in $\text{In}_2\text{Br}_6(\text{g})$.

[2]

[Total: 17]

10

Oct/Nov 2021 9701/22 · Q2 (a)(i), (a)(ii), (a)(iii), (a)(v), (b), (c), (d)(i), (d)(ii), (d)(iii) (cont.)

- (a) Construct an equation to represent the **first** ionisation energy of oxygen.
Include state symbols.

..... [1]

- (b) (i) State and explain the general trend in first ionisation energies across Period 2.

.....
.....
.....
.....
..... [3]

- (ii) Explain why ionisation energy **A** in Fig. 1.1 does **not** follow the general trend in first ionisation energies across Period 2.

.....
.....
.....
..... [2]

- (c) Element **E** is in Period 3 of the Periodic Table.
The first eight ionisation energy values of **E** are shown in Table 1.1.

Table 1.1

ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
ionisation energy / kJ mol ⁻¹	577	1820	2740	11 600	14 800	18 400	23 400	27 500

Deduce the full electronic configuration of **E**.
Explain your answer.

full electronic configuration of **E** =

explanation

.....

.....

[3]

[Total: 9]

March 2022 9701/22 · Q1 (a), (b)(i), (b)(ii), (c) (cont.)

- (a) Identify the highest energy orbital which contains electrons in a calcium atom. Sketch the shape of this orbital.

identity of highest energy orbital in Ca

shape

[1]

- (c) Predict what you would observe when aqueous radium chloride is added to aqueous sodium sulfate.

Do **not** refer to temperature changes in your answer.

.....

..... [1]

- (d) (i) $^{25}_{12}\text{Mg}$ is an isotope of magnesium.

Determine the number of protons and neutrons in an atom of $^{25}_{12}\text{Mg}$.

number of protons

number of neutrons

[1]

- (ii) State the full electronic configuration of an atom of $^{25}_{12}\text{Mg}$.

..... [1]

- (ii) Calculate the mass of **X**. Use data from Table 1.1 and A_r (magnesium) = 24.31 in your calculation. Show your working.

mass of **X** =

[2]

(iii) State **one** similarity and **one** difference in the properties of these isotopes of magnesium. Explain your answer.

.....

.....

..... [2]

- 1 (a) Define first ionisation energy.

.....

 [2]

- (b) Successive ionisation energies for element **A** are shown in Table 1.1.

Table 1.1

ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
ionisation energy / kJ mol ⁻¹	1310	3390	5320	7450	11 000	13 300	71 000	84 100

Use Table 1.1 to deduce the group of the Periodic Table that **A** belongs to. Explain your answer.

Group

..... [1]

- (c) Across Period 3 there is a general trend for first ionisation energies to increase due to the increase in attraction between the nucleus and the outer electron.

Explain why the first ionisation energy of sulfur is less than the first ionisation energy of phosphorus.

.....

 [2]

- (d) In an Al^{2+} ion the nuclear attraction for the outer electron is stronger than in an atom of Na.

Compare the electronic structures of Al^{2+} and an atom of Na and explain why the third ionisation energy of aluminium is greater than the first ionisation energy of sodium.

.....

 [2]

3

- (e) An isotope of copper has a relative isotopic mass of 65.

Complete Table 1.2 for an atom of copper-65.

Table 1.2

	atomic number	nucleon number	number of neutrons	electronic arrangement
copper-65				

[3]

- (f) (i) The element copper has a relative atomic mass of 63.5.

Calculate how many atoms are present in 1.05 g of copper.

atoms of copper present = [1]

(ii) Copper has a melting point of 1085 °C and a high electrical conductivity.

Explain these properties of copper by referring to its structure and bonding.

.....

 [2]

[Total: 13]

(a) Gallium has two stable isotopes, ^{69}Ga and ^{71}Ga .

(i) Complete Table 1.1 to show the numbers of protons, neutrons and electrons in the two stable isotopes of gallium.

Table 1.1

isotope	number of protons	number of neutrons	number of electrons
^{69}Ga			
^{71}Ga			

[2]

(b) Potassium also has two stable isotopes. Both isotopes have the same chemical properties.

(i) Explain why both isotopes of potassium have the same chemical properties.

.....
..... [1]

(ii) State the full electronic configuration of an atom of potassium.

..... [1]

Oct/Nov 2022 9701/23 · Q1 (a)(i), (b)(i), (b)(ii), (b)(iii) (continued ·)

- (iii) The first, second and third ionisation energies of potassium are 418, 3070 and 4600 kJ mol⁻¹, respectively.

Use this information to explain why potassium is in Group 1.

.....

.....

.....

..... [2]

[Total: 10]

(a) Complete Table 1.1.

Table 1.1

	nucleon number	number of neutrons	number of electrons
^{130}Te			

[3]

(b) Identify the sub-shell in an atom of Te that contains electrons with the lowest energy.

..... [1]

(c) Construct an equation to represent the first ionisation energy of Te.

..... [1]

(d) (i) The radius of Te ions decreases after each successive ionisation.

State **two** factors that are responsible for the increase in the first six ionisation energies of Te.

.....

.....

..... [2]

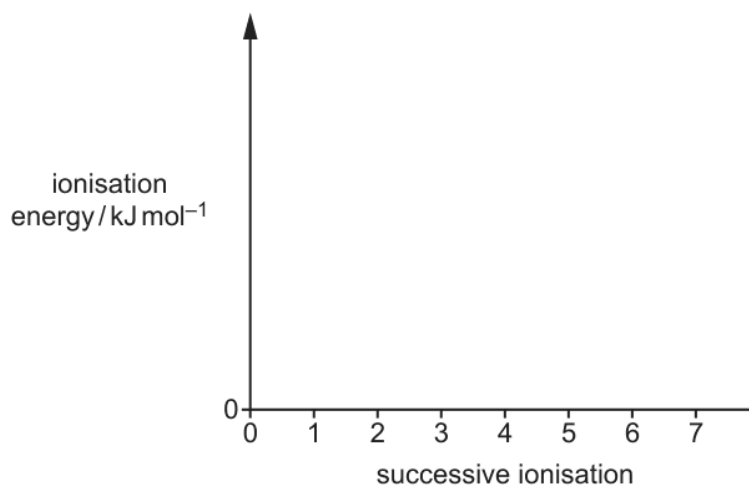
(ii) Sketch a graph in Fig. 1.1 to show the trend in the first **seven** ionisation energies of Te.

Fig. 1.1

[2]

(ii) Name the type of reaction that occurs when TeF_x reacts with water.

..... [1]

[Total: 13]

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[Turn over

4

May/June 2023 9701/21 · Q1 (a), (b), (c), (d)(ii), (f)(ii) (cont.)

(iii) State the full electronic configuration of Cu^{2+} .

..... [1]

[Total: 9]

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9701/23/M/J/23

[Turn over

6

May/June 2023 9701/23 · Q1 (d)(iii)

- 1 (a) Complete Table 1.1 using relevant information from the Periodic Table.

Table 1.1

	nucleon number	proton number	number of electrons
Mg^{2+}	24		
Al^{3+}	27		

[2]

- (b) State and explain the difference in the ionic radius of Al^{3+} compared to Mg^{2+} .

.....

 [3]

- (c) Draw a labelled diagram to show the structure and bonding in sodium.

[1]

- (ii) Complete Fig. 1.1 to show the variation in the melting points of the elements P, S and Cl.
[2]

- (ii) The solutions made in column 3 of Table 1.2 are mixed together.
Name the type of reaction that occurs.

..... [1]

- (f) Aluminium hydroxide is amphoteric.

- (i) Explain what is meant by amphoteric.

.....
 [1]

May/June 2024 9701/22 · Q1 (a), (b), (c), (d)(ii), (e)(ii), (f)(i), (f)(ii) (continued ·)

- (ii) Write an equation to describe the reaction that occurs when aluminium hydroxide, $Al(OH)_3$, reacts with $NaOH(aq)$.

..... [1]

[Total: 15]

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4

Turn over

May/June 2024 9701/22 · Q1 (a), (b), (c), (d)(ii), (e)(ii), (f)(i), (f)(ii) (cont.)

- (c) Determine the full electronic configuration of Fe^{3+} .

..... [1]

May/June 2024 9701/22 · Q3 (c)

- [1]

- Draw the shape of a 1s orbital.

[1]

- [1]

Table 1.1

isotope	number of protons	number of neutrons	total number of electron shells
$^{103}_{45}\text{Rh}$		58	
$^{191}_{77}\text{Ir}$			6
$^{193}_{77}\text{Ir}$			6

[3]

(c) Table 1.2 shows the relative abundances of isotopes in a sample of an alloy containing rhodium and iridium only.

Table 1.2

isotope	relative isotopic mass	relative abundance in alloy
$^{103}_{45}\text{Rh}$	102.91	50.00
$^{191}_{77}\text{Ir}$	190.96	15.18
$^{193}_{77}\text{Ir}$	192.96	34.82

(i) Define relative isotopic mass.

.....
.....
..... [2]

(iii) Explain how the conversion of ethene to but-2-ene can be described as an addition reaction.

.....
..... [1]

(c) Fig. 3.1 shows a sketch of some of the ionisation energies of silicon, Si.

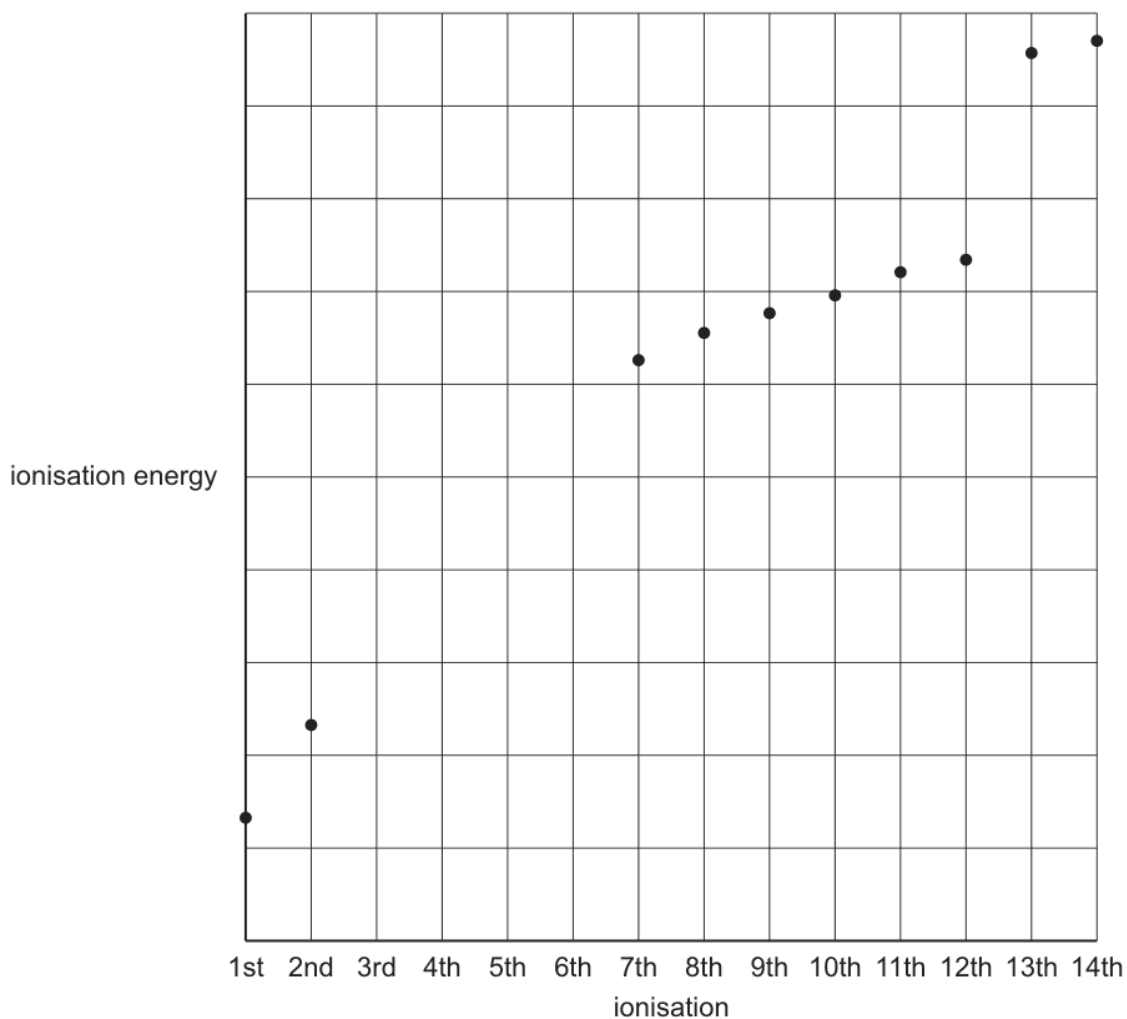


Fig. 3.1

(i) Complete the graph in Fig. 3.1 to show the third to sixth ionisation energies of Si.

[2]

(ii) Construct an equation to represent the second ionisation energy of Si.

..... [1]



Oct/Nov 2024 9701/21 · Q3 (c)(i), (c)(ii)

(a) The shorthand electronic configuration of vanadium in the ground state is $[\text{Ar}]3d^34s^2$.

(i) State what is meant by the term ground state.

..... [1]

(ii) Show the electronic configuration of vanadium using electrons in boxes notation.

$[\text{Ar}]$

--	--	--	--	--	--

 [1]

(iii) Deduce the total number of electrons in the p sub-shells of a vanadium atom.

..... [1]

(b) Pelopium was the suggested name for a new element discovered in a mineral.

Pelopium was later found to be a mixture of niobium, Nb, and tantalum, Ta.

Only one naturally occurring isotope exists for each of Nb and Ta.

(i) Complete Table 1.1.

Table 1.1

isotope	relative isotopic mass	number of protons	number of neutrons
$^{93}_{41}\text{Nb}$	92.91		
$^{181}_{73}\text{Ta}$	180.95		

[2]

(ii) Define relative isotopic mass.

.....
.....
..... [2]



(c) Fig. 3.1 shows a sketch of some of the ionisation energies of phosphorus, P.

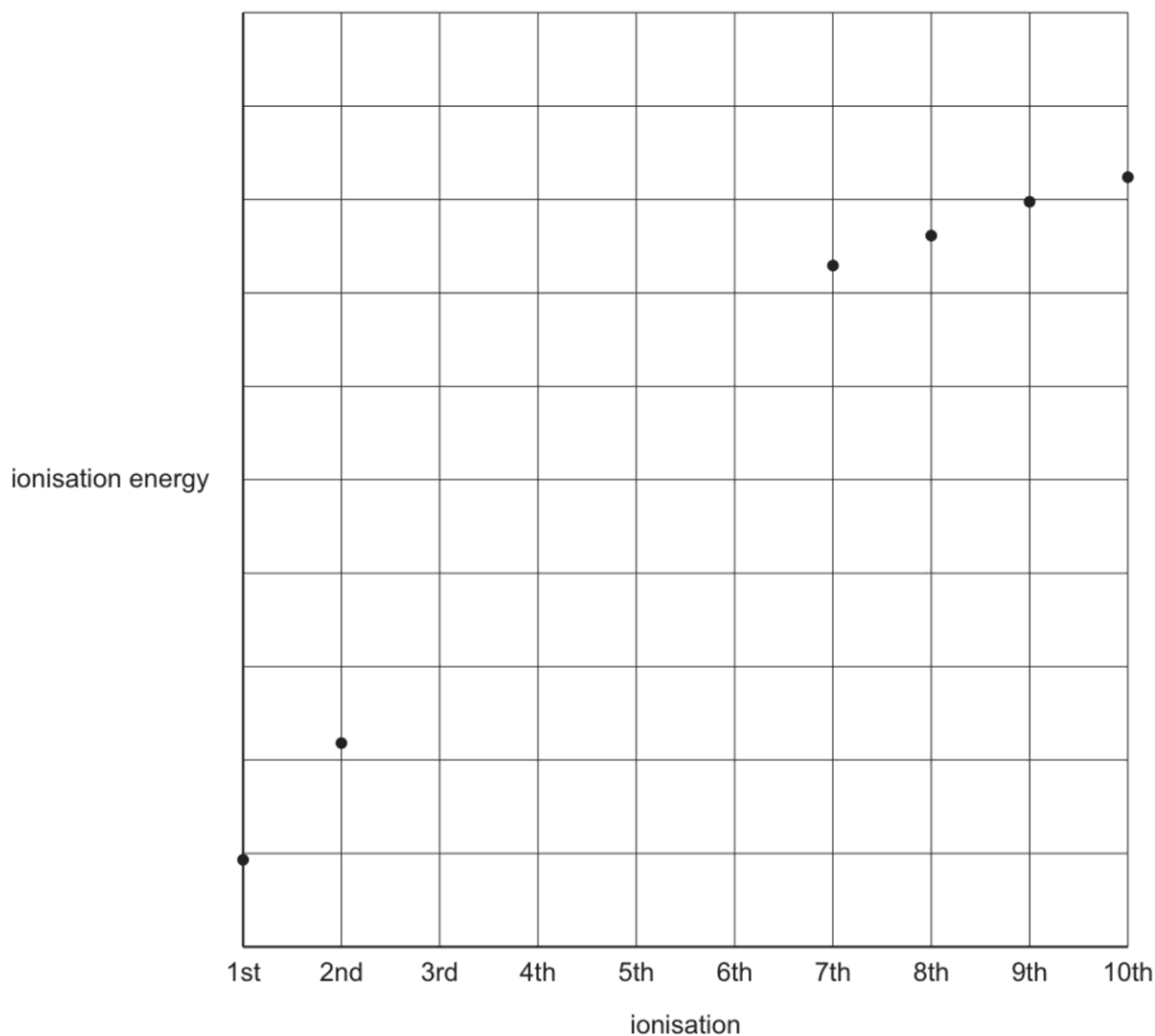


Fig. 3.1

(i) Construct an equation to represent the third ionisation energy of P.

..... [1]

(ii) Complete the graph in Fig. 3.1 to show the third to sixth ionisation energies of P.

[2]



(b) Table 1.1 gives some details of the stable naturally occurring isotopes of rhodium and iridium.

Table 1.1

isotope	number of protons	number of neutrons	total number of electron shells
$^{103}_{45}\text{Rh}$		58	
$^{191}_{77}\text{Ir}$			6
$^{193}_{77}\text{Ir}$			6

Complete Table 1.1.

[3]



9701/23/O/N/24
3

Oct/Nov 2024 9701/23 · Q1 (b)

(ii) Construct an equation to represent the second ionisation energy of Si.

..... [1]



9701/23/O/N/24
10

[Turn over]

Oct/Nov 2024 9701/23 · Q3 (c)(ii)

(ii) Table 2.1 shows successive ionisation energy values for beryllium, Be.

Table 2.1

	1st	2nd	3rd	4th
ionisation energy / kJ mol ⁻¹	900	1760	14 800	21 000

Use Table 2.1 to state and explain:

- the general trend in these values
- the significance of the large difference between the 2nd and 3rd ionisation energies.

.....

.....

.....

..... [2]



(ii) Complete Table 2.2 to show the numbers of protons and neutrons in the isotopes of magnesium.

Table 2.2

isotope	number of protons	number of neutrons
magnesium-24		
magnesium-25		
magnesium-26		

[2]

(a) Define isotopes.

.....

.....

..... [1]

(ii) Complete Table 2.1 to show the number of protons and nucleons in one atom of ⁵⁶Fe.

Table 2.1

particle	number of particles in one atom of ⁵⁶ Fe
protons	
nucleons	

[2]

(c) Deduce the number of pairs of electrons in the shell with principal quantum number $n = 3$ in an Fe atom.

number of pairs of electrons [1]

(d) Write an equation to represent the first ionisation energy of iron.

..... [1]

- (e) Suggest how the value for the first ionisation energy of ^{54}Fe compares to the first ionisation energy of ^{56}Fe . Explain your answer in terms of the factors that affect ionisation energy.
-
-
-
-
- [4]

[Total: 11]

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6

[Turn over]

- (a) (i) Give the full electronic configuration of a fluorine atom.

..... [1]

- (ii) Deduce the number of pairs of electrons in the second energy shell, $n = 2$, of an oxygen atom.

..... [1]

- (iii) Draw the shape of the highest energy orbital that contains electrons in an atom of calcium.

[1]

- (b) (i) Write an equation to represent the first ionisation energy of sulfur.

..... [1]

- (ii) Explain why the first ionisation energy of sulfur is less than the first ionisation energy of phosphorus.

.....
.....
.....
..... [2]

- (iii) Arrange the three species F^- , Ne and Na^+ in order of increasing radius.

Explain your answer.

..... < <
smallest radius largest radius

.....
.....
.....
..... [4]

[Total: 10]



(c) The **third** ionisation energies of the Period 3 elements are shown in Fig. 1.2.

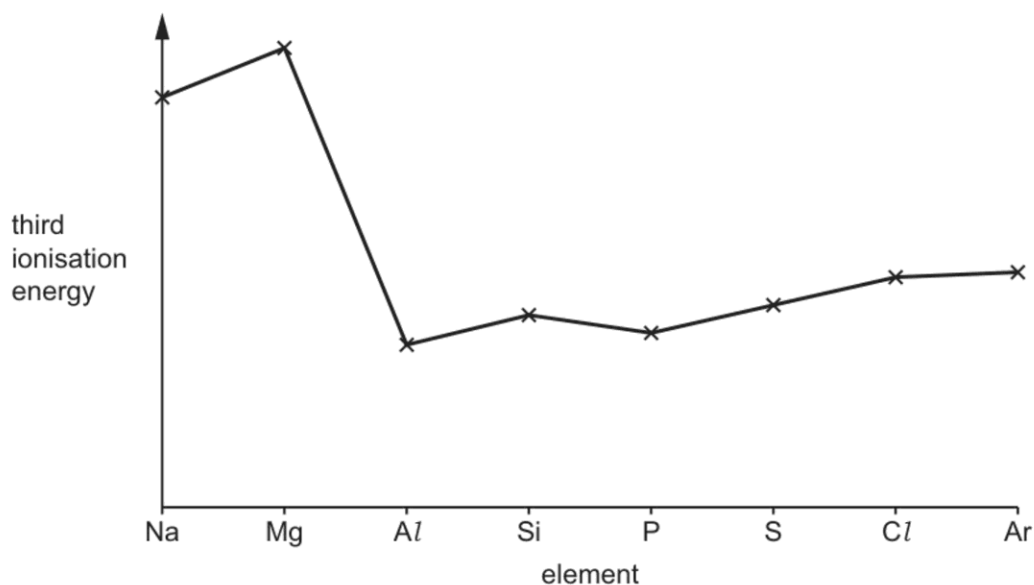


Fig. 1.2

- (i) Write an equation, including state symbols, to represent the **third** ionisation energy of argon.

..... [2]

- (ii) The differences in the values for third ionisation energy shown in Fig. 1.2 are due to differences in the strength of attraction between the nucleus and the outer electron of each ion.

State **two** factors that affect the strength of attraction between the nucleus and the outer electron.

1

2 [2]

- (iv) In the third ionisation energy of argon, the ion produced has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^3$.

Complete Fig. 1.3 to show the arrangement of electrons in the orbitals of this ion.

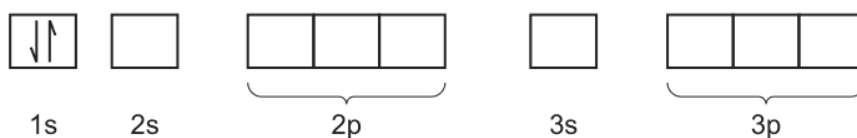


Fig. 1.3

[1]

(a) Cr exists as four stable isotopes.

(i) The most common isotope of Cr is chromium-52.

Determine the number of protons, neutrons and electrons in an atom of chromium-52.

number of protons neutrons electrons [1]

(ii) Describe how an atom of chromium-54 differs from an atom of chromium-52. Refer to numbers of particles in your answer.

..... [1]

(b) The shorthand electronic configuration of chromium is $[\text{Ar}] 3d^5 4s^1$.

(i) Complete the full electronic configuration of chromium.

..... $3d^5 4s^1$ [1]

(ii) Deduce the total number of unpaired electrons in an atom of chromium.

..... [1]



- (iii) $\text{CrO}_4^{2-}(\text{aq})$ ions are yellow and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ ions are orange.

State what is observed when the following changes are made to an equilibrium mixture of acidified $\text{CrO}_4^{2-}(\text{aq})$ and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ ions.

Explain your answers.

- The equilibrium mixture is warmed gently.

observation

explanation

.....

.....

- Dilute $\text{HCl}(\text{aq})$ is added to the equilibrium mixture.

observation

explanation

.....

.....

[4]

- (e) Chromium(IV) fluoride, CrF_4 , is a covalent molecule that shows similar chemical properties to SiCl_4 .

Suggest the type of reaction that occurs when CrF_4 is placed in water.

Construct a relevant equation for this reaction.

type of reaction

equation

[2]

[Total: 20]





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6

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(a) Mn is usually found as a single isotope, manganese-55.

(i) Determine the number of protons, neutrons and electrons in an atom of manganese-55.

number of protons neutrons electrons [1]

(ii) Define isotopes.

.....
..... [1]

(b) The shorthand electronic configuration of manganese is [Ar] $3d^5 4s^2$.

(i) Complete the full electronic configuration of manganese.

..... $3d^5 4s^2$ [1]

(ii) Deduce the total number of unpaired electrons in an atom of manganese.

..... [1]

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(ii) Deduce the total number of unpaired electrons in an atom of chromium.

..... [1]

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3



- (e) Chromium(IV) fluoride, CrF_4 , is a covalent molecule that shows similar chemical properties to SiCl_4 .

Suggest the type of reaction that occurs when CrF_4 is placed in water.

Construct a relevant equation for this reaction.

type of reaction

equation [2]

[Total: 20]

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