Q1.

Which statement is **not** correct about the Period 3 elements sodium to chlorine?

A Sodium has the largest atomic radius. ⬭

B Sodium has the lowest melting point. ⬭

C Silicon has the highest melting point. ⬭

D Chlorine has the highest first ionisation energy. ⬭

(Total 1 mark)

Q2.

Which element in Period 3 has the highest melting point?

A Aluminium ⬭

B Silicon ⬭

C Sodium ⬭

D Sulfur ⬭

(Total 1 mark)

Q3.

Which ion has the largest radius?

A F^- ⬭

B Mg^{2+} ⬭

C Na^+ ⬭

D O^{2-} ⬭

(Total 1 mark)

Q4.

Which element has a first ionisation energy lower than that of sulfur?

A Chlorine ⬭

B Oxygen ⬭

C Phosphorus ⬭

D Selenium ⬭

Q5.

This question is about elements in Period 3 and their compounds.

(a) When a piece of sodium is added to 200 cm^3 of water in a large beaker a vigorous reaction occurs. The temperature of the water increases by 25 ^oC

Give an equation, including state symbols, for the reaction of sodium with water. Suggest why it is dangerous to react a similar piece of sodium with 10 cm^3 of water in a boiling tube.

Equation

_____

Why it is dangerous _____

_____

_____

(2)

(b) Give an equation for the reaction of phosphorus(V) oxide with water.

Suggest a pH for the solution formed.

Equation

_____

pH _____

(2)

(c) Explain, in terms of crystal structure and bonding, why silicon(IV) oxide has a higher melting point than phosphorus(V) oxide.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(d) An element in Period 3 forms an oxide that is insoluble in water.
This oxide reacts with sulfuric acid and with aqueous potassium hydroxide.

Give the formula for this oxide.

Give an equation for the reaction of this oxide with sulfuric acid.

Formula _____

Equation

_____

(2)

(e) Give the formula of a hydroxide of an element in Period 3 used in medicine.

_____

(1)

(f) Identify the element in Period 3, from sodium to chlorine, that has the largest atomic radius.

_____

(1)

(Total 12 marks)

Q6.

This question is about atomic structure.

(a) There is a general trend for an increase in ionisation energy across Period 3. Give **one** example of an element that deviates from this trend.

Explain why this deviation occurs.

Element _____

Explanation _____

_____

_____

_____

_____

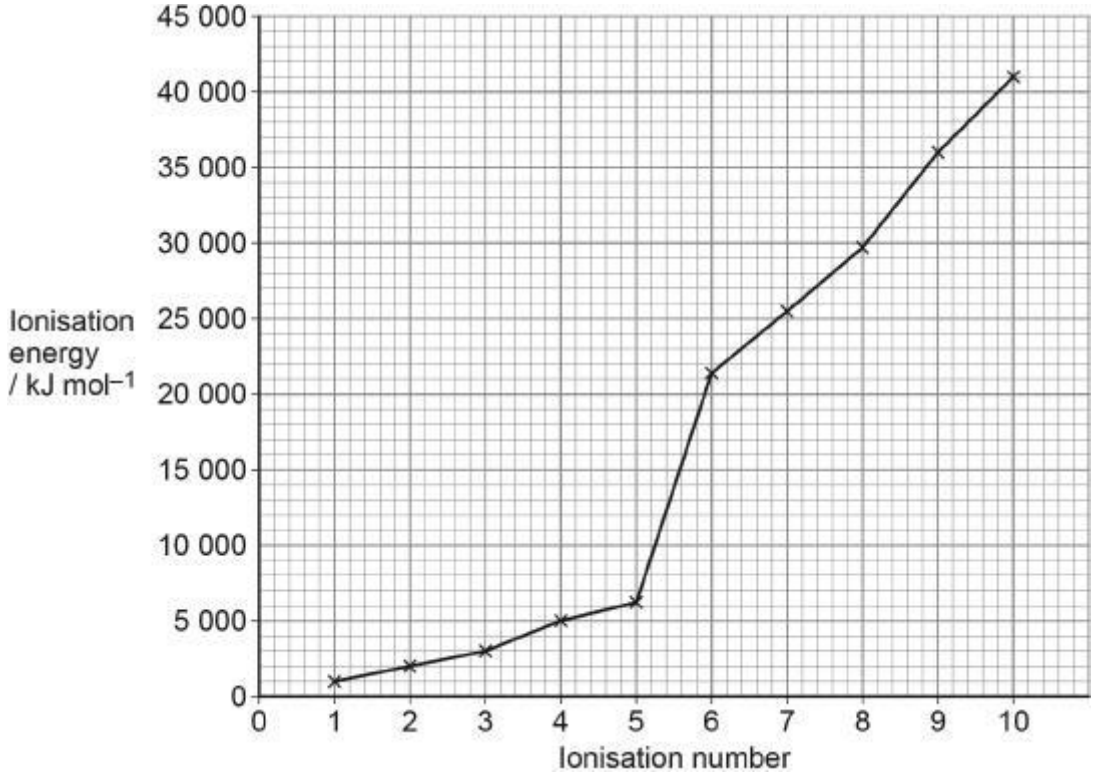
(3)

(b) Give an equation, including state symbols, to represent the process that occurs when the **third** ionisation energy of sodium is measured.

_____

(1)

(c) The graph shows the successive ionisation energies of a Period 3 element, **X**.



Identify element **X**.
Explain your choice.

Element _____

Explanation _____

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q7.

Which represents the correct order of increasing radius of the ions?

A F^- O^{2-} Li^+ Be^{2+} ⬭

B Li^+ Be^{2+} O^{2-} F^- ⬭

C Be^{2+} Li^+ F^- O^{2-} ⬭

D O^{2-} F^- Li^+ Be^{2+} ⬭

(Total 1 mark)

Q8.

Which of these elements has the highest melting point?

A Argon ⬭

B Chlorine ⬭

C Silicon ⬭

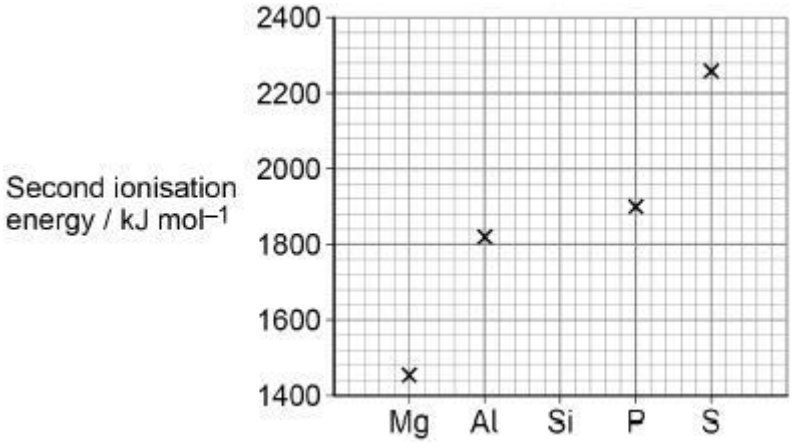
D Sulfur ⬭

(Total 1 mark)

Q9.

This question is about Period 3 elements.

The graph shows the **second** ionisation energies of some elements in Period 3.



(a) Draw a cross (x) on the graph above to show the **second** ionisation energy of silicon.

(1)

(b) Identify the element in Period 3, from sodium to argon, that has the highest **second** ionisation energy.

Give an equation, including state symbols, to show the process that occurs when the **second** ionisation energy of this element is measured.

If you were unable to identify the element you may use the symbol **Q** in your equation.

Element _____

Equation

_____

(2)

(c) Explain why the atomic radius decreases across Period 3, from sodium to chlorine.

_____

_____

_____

(2)

(d) Identify the element in Period 3, from Na to Cl, that has the highest electronegativity.

_____

(1)

(e) Phosphorus burns in air to form phosphorus(V) oxide.
Give an equation for this reaction.

_____

(1)

(Total 7 marks)

Q10.

This question is about compounds that contain fluorine.

(a) Sodium fluoride contains sodium ions (Na^+) and fluoride ions (F^-).
Na^+ and F^- have the same electron configuration.

Explain why a fluoride ion is larger than a sodium ion.

_____

_____

_____

_____

_____

(2)

(b) Explain, in terms of structure and bonding, why the melting point of sodium fluoride is high.

(2)

(c) The ion H_2F^+ is formed when hydrogen fluoride gains a proton as shown in the equation

$$HF + H^+ \rightarrow H_2F^+$$

Name the type of bond formed when HF reacts with H^+
Explain how this bond is formed.

Type of bond _____

Explanation _____

(2)

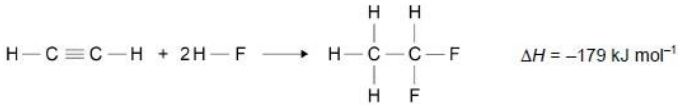
(d) Fluoroantimonic acid contains two ions, SbF_6^- and H_2F^+

Draw the shape of the SbF_6^- ion and the shape of the H_2F^+ ion. Include any lone pairs that influence the shape. Name the shape of each ion.

	SbF_6^-	H_2F^+
Shape		
Name of shape		

(4)

(e) Hydrogen fluoride reacts with ethyne (C_2H_2) as shown in the equation. All compounds are in the gaseous state.



The table shows some mean bond enthalpy data.

Bond	C–H	C≡C	H–F	C–C
Mean bond enthalpy / kJ mol^{-1}	412	837	562	348

Use the data in the table above to calculate a value for the bond enthalpy of a C–F bond in the product.

C–F bond enthalpy _____ kJ mol^{-1}

(3)

(Total 13 marks)

Q11.

This question is about periodicity, the Period 4 elements and their compounds.

(a) State the meaning of the term periodicity.

_____

_____

_____

(1)

(b) Identify the element in Period 4 with the highest electronegativity value.

_____

(1)

(c) Identify the element in Period 4 with the largest atomic radius.

Explain your answer.

Element _____

Explanation _____

_____

_____

_____

(3)

(d) The equations for two reactions of arsenic(III) oxide are shown.

$$As_2O_3 + 6\ HCl \rightarrow 2\ AsCl_3 + 3\ H_2O$$

$$As_2O_3 + 6\ NaOH \rightarrow 2\ Na_3AsO_3 + 3\ H_2O$$

Name the property of arsenic(III) oxide that describes its ability to react in these two ways.

_____

(1)

(e) Complete the equation for the formation of arsenic hydride.

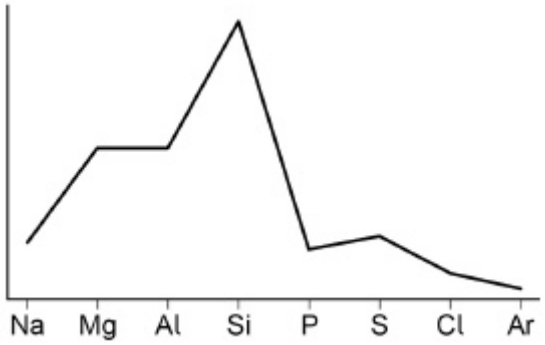
As_2O_3 + Zn + $HNO_3 \rightarrow$ AsH_3 + $Zn(NO_3)_2$ + H_2O

(1)

(Total 7 marks)

Q12.

The diagram shows how a property of Period 3 elements varies across the period.



What is the property?

A Atomic radius ⬭

B Electronegativity ⬭

C First ionisation energy ⬭

D Melting point ⬭

(Total 1 mark)

Q13.

Which element has the highest first ionisation energy?

A Aluminium ⬭

B Phosphorus ⬭

C Silicon ⬭

D Sulfur ⬭

(Total 1 mark)

Q14.

Which of these Period 3 elements has the highest melting point?

A Aluminium ⬭

B Phosphorus ⬭

C Sodium ⬭

D Sulfur ⬭

(Total 1 mark)

Q15.

This question is about atomic structure.

(a) Write the full electron configuration for each of the following species.

Cl^- _____

Fe^{2+} _____

(2)

(b) Write an equation, including state symbols, to represent the process that occurs when the third ionisation energy of manganese is measured.

_____

_____

(1)

(c) State which of the elements magnesium and aluminium has the lower first ionisation energy.

Explain your answer.

_____

_____

_____

_____

_____

_____

_____

(3)

(d) A sample of nickel was analysed in a time of flight (TOF) mass spectrometer. The sample was ionised by electron impact ionisation. The spectrum produced showed three peaks with abundances as set out in the table.

m/z	Abundance / %
58	61.0
60	29.1
61	9.9

Give the symbol, including mass number, of the ion that would reach the detector first in the sample.

Calculate the relative atomic mass of the nickel in the sample.

Give your answer to one decimal place.

Symbol of ion _____

Relative atomic mass _____

(3)

(Total 9 marks)

Q16.

Which is the correct order of melting points of these Period 3 elements?

A phosphorus > sulfur > chlorine > argon ⬭

B argon > chlorine > phosphorus > sulfur ⬭

C sulfur > phosphorus > chlorine > argon ⬭

D chlorine > phosphorus > sulfur > argon ⬭

(Total 1 mark)

Q17.

Which of the following is a correct statement about the trend in atomic radius across Period 3 of the Periodic Table?

A	radius increases because the atoms have more electrons	⬭
B	radius decreases because nuclear charge increases	⬭
C	radius increases because shielding (screening) increases	⬭
D	radius decreases because shielding (screening) decreases	⬭

(Total 1 mark)

Q18.

Which elements are shown in increasing order of the stated property?

A	Atomic radius: phosphorus, sulfur, chlorine.	⬭
B	First ionisation energy: sodium, magnesium, aluminium.	⬭
C	Electronegativity: sulfur, phosphorus, silicon.	⬭
D	Melting point: argon, chlorine, sulfur.	⬭

(Total 1 mark)

Mark scheme

Q1.

B

Sodium has the lowest melting point.

[1]

Q2.

B

Silicon

[1]

Q3.

D

O^{2-}

[1]

Q4.

D

Selenium

[1]

Q5.

(a) $2\ Na(s) + 2\ H_2O(l) \rightarrow 2\ NaOH(aq) + H_2(g)$

Allow ionic equations

Allow multiples

1

Temperature will go up more **or** reactants can shoot out of the tube

Allow the mixture could explode or glass could shatter or hydrogen could ignite/is flammable

Ignore reaction is exothermic/vigorous

1

(b) $P_4O_{10} + 6\ H_2O \rightarrow 4\ H_3PO_4$

Allow ionic equations

1

Allow –1 to + 1

Do not allow equations from P_2O_5

1

(c) M1 SiO_2 is macromolecular / giant covalent / giant molecule

Do not allow giant, giant atomic or giant ionic

1

M2 Strong covalent bonds (between atoms) or covalent bonds need a lot of

energy to be broken/overcome

1

M3 P_4O_{10} is <u>molecular</u> or <u>simple covalent molecule</u>

1

M4 Weak van der Waals forces <u>between molecules</u> or van der Waals forces <u>between molecules</u> break easily

1

(d) Al_2O_3

1

$Al_2O_3 + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\ H_2O$
or $Al_2O_3 + 6\ H^+ \rightarrow 2\ Al^{3+} + 3\ H_2O$

1

(e) $Mg(OH)_2$

1

(f) Na / sodium

1

[12]

Q6.

(a) Aluminium / Al

*Allow **M2/M3** if a Group 3 element is given*

1

(Outer) electron in (3)<u>p</u> orbital / sub-shell (level)

Not energy level

1

(3p) higher in energy / slightly more shielded (than 3s) / slightly further away (than 3s)

1

or

OR

Sulfur / S

*Allow **M2/M3** if a Group 6 element is given*

1

(Outer) electrons in (3)p orbital begin to <u>pair</u>

Do not allow just p^4 vs p^3

1

Repel

1

(b) $Na^{2+}(g) \rightarrow Na^{3+}(g) + e^-$

State symbols essential.

Allow
$Na^{2+}(g) + e^- \rightarrow Na^{3+}(g) + 2\ e^-$

1

(c) **M1** Phosphorus / P

Mark independently

M2 large jump in ionisation energy for the 6th ionisation energy

Large jump after the 5 e^- is removed / when the 6th e^- is removed

M3 This is when the electron is being removed from the 2nd (principle) energy level / from a lower energy level / from a lower shell / from 2p / from an energy level that is closer to the nucleus

3

[7]

Q7.

C

Be^{2+} Li^+ F^- O^{2-}

[1]

Q8.

C

Silicon

[1]

Q9.

(a) Cross at 1580

Allow a cross drawn for Si that is between the values for Mg and Al

1

(b) **M1** Na

1

M2 $Na^+(g) \rightarrow Na^{2+}(g) + e^-$

***M2** Allow $Q^+(g) \rightarrow Q^{2+}(g) + e^-$*

State symbols essential

Allow correct equation consequential on their element

1

(c) The number of protons increases OR nuclear charge increases

1

Shielding is similar/same OR electrons are added to the same shell

Allow same number of shells

1

(d) Chlorine/Cl

1

(e) $4P + 5O_2 \rightarrow P_4O_{10}$ OR $P_4 + 5O_2 \rightarrow P_4O_{10}$

Allow multiples

Ignore state symbols

Do not allow equations with P_2O_5

1

[7]

Q10.

(a) Fluoride ion has (two) fewer protons/lower nuclear charge

Do not allow fluorine, but allow fluorine ion.

Any reference to different numbers of electrons in the ions loses M1

1

Weaker attraction between nucleus and (outer) electrons

Allow answers in terms of sodium ion but must be explicit.

Ignore references to atomic radius

1

(b) (Electrostatic) forces of attraction between oppositely charged ions/Na^+ and F^-

Mention of IMF, covalent, macromolecular, metallic, electronegativity of ions loses both marks

1

Lots of energy needed to overcome/break forces

Allow strong ionic bonding

Allow strong forces/bonds of attraction (need to be broken)

1

(c) Type of Bond: Coordinate bond / dative (covalent) bond

If just covalent, then do not award M1 but mark on

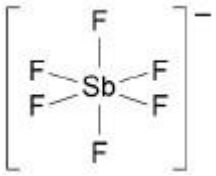
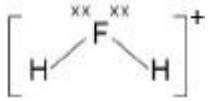
1

Explanation: A (lone) pair of electrons is donated from F

Allow both electrons (in the shared pair) come from F

1

(d)

Shape		
Name of shape	Octahedral	Bent / V-shaped / angular

Lone pairs on H_2F^+ are essential (can be shown in lobes)

Ignore missing charges

Mark independently

4

(e) ΔH = ΣΔH(Bonds broken) - ΣΔH(Bonds Formed)

Allow M1 if 2785 and 1996 seen (or allow M1 if 1961 and 1172 seen)

-179 = 2(412) + 837 + 2(562) – [348 + 4(412) + 2(C—F)]

1

-179 = 2785 – (1996 +2(C—F))

2(C—F) = 968

M3 consequential on any M2 if it is clear that M2 is for 2(C-F)

1

C—F = 484

-484 scores 2

1

[13]

Q11.

(a) Repeating pattern/trends (of physical or chemical properties/reactions)

Allow named property

Penalise groups

1

(b) Bromine/Br

Not Br_2

Accept Kr or Krypton

1

(c) Potassium /K

*If Na or Rb lose **M1** but allow access to **M2** and **M3***

If other incorrect elements 0/3

1

Smallest number of protons/smallest nuclear charge

1

Similar shielding / same number of shells (as other elements in period 4)

Allow same shielding

1

(d) Amphoteric

1

(e) $As_2O_3 + 6\ Zn + 12\ HNO_3 \rightarrow 2\ AsH_3 + 6\ Zn(NO_3)_2 + 3\ H_2O$

Accept multiples

1

[7]

Q12.

D

[1]

Q13.

B

[1]

Q14.

A

[1]

Q15.

(a) Cl^- $1s^2 2s^2 2p^6 3s^2 3p^6$

1

Fe^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

1

If [Ne] or [Ar] used then Max 1if both correct

Ignore $4s^0$

Allow subscripts

(b) $Mn^{2+}(g) \longrightarrow Mn^{3+}(g) + e^-$

1

States symbols are required

Allow $Mn^{2+}(g) - e^- \longrightarrow Mn^{3+}(g)$

Negative charge needed on electron

(c) Al

Mg then CE = 0

1

(Outer) electron in (3)p sublevel / orbital

Not just level or shell

1

Higher in energy / further from the nucleus
so easier to remove OWTTE

Both required for M3

1

Ignore shielding

(d) $^{58}Ni^+$

M1 needs mass and charge – allow subscripts

1

A_r= [(58 × 61.0) + (60 × 29.1) + (61 × 9.9)] / 100

1

A_r= 58.9 must be to 1dp

1

[9]

Q16.

C

[1]

Q17.

B

[1]

Q18.

D