CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



EXAM QUESTION PACK

9 THE PERIODIC TABLE, CHEMICAL PERIODICITY

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Chapter 9

The Periodic Table: chemical periodicity

9.1 Periodicity of physical properties of the elements in Period 3

452. 9701_m21_qp_12 Q: 13

Which row is correct?

	statement	reason
A	The first ionisation energy of phosphorus is greater than that of magnesium.	electron is lost from a 3p orbital in both cases
B	The melting point of phosphorus is greater than that of magnesium.	phosphorus has more valence electrons than magnesium
C	The atomic radius of phosphorus is smaller than that of magnesium.	phosphorus has greater nuclear charge than magnesium
D	The electrical conductivity of phosphorus is smaller than that of magnesium.	bonding changes from ionic in magnesium to covalent in phosphorus

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453. 9701_s19_qp_12 Q: 14

Elements D and E are both in Period 3. Element D has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element E. Elements D and E react together to form compound L.

Which compound could be L?

A $MgCl_2$ **B** MgS **C** Na_2S **D** PCl_3

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454. 9701_s19_qp_13 Q: 12

Sodium and sulfur react together to form sodium sulfide, Na_2S.

How do the atomic radius and ionic radius of sodium compare with those of sulfur?

	atomic radius	ionic radius
A	sodium < sulfur	sodium > sulfur
B	sodium < sulfur	sodium < sulfur
C	sodium > sulfur	sodium > sulfur
D	sodium > sulfur	sodium < sulfur

---

455. 9701_w19_qp_11 Q: 13

X, Y and Z are consecutive elements in Period 3 of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of X, Y and Z?

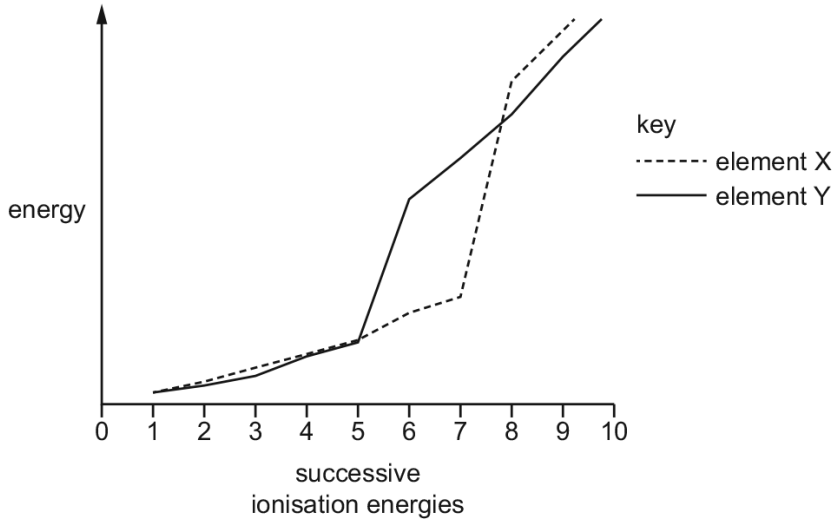
	X	Y	Z
A	Na	Mg	Al
B	Mg	Al	Si
C	Al	Si	P
D	Si	P	S

---

456. 9701_w19_qp_12 Q: 3

The graph shows the successive ionisation energies of element X and element Y.

Both elements are in Period 3.



Which statement is correct?

A An atom of element X needs one extra electron for a full outer shell; an atom of element Y needs three extra electrons for a full outer shell.

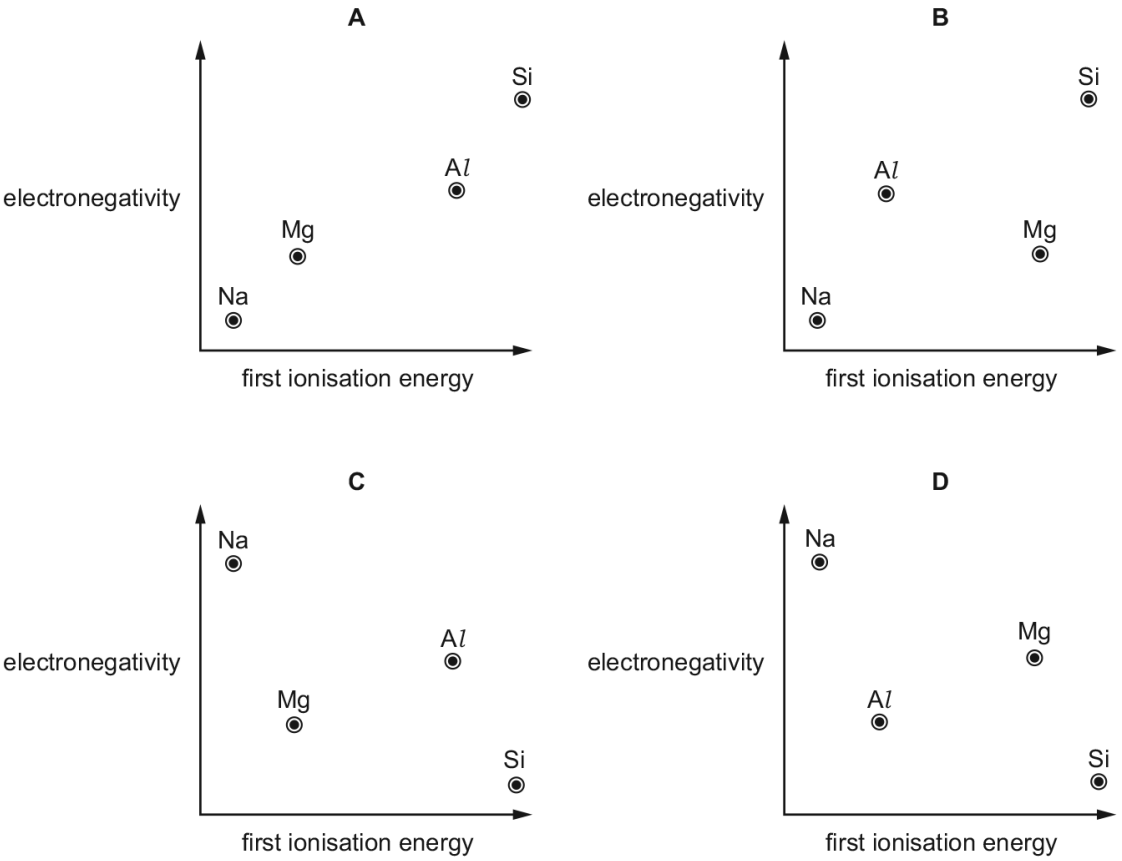
B An atom of element Y has five electrons in the 3p subshell.

C Element X has an oxidation number of +7 in most of its compounds.

D When element X combines with element Y, the bonding is ionic.

457. 9701_w19_qp_12 Q: 12

Which diagram correctly shows the electronegativity of the elements Na, Mg, Al and Si plotted against their first ionisation energies?



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458. 9701_w18_qp_12 Q: 3

Rubidium and bromine form ions that are isoelectronic. Each ion has 36 electrons.

Which row is correct?

	rubidium radii	bromine / bromide radii
A	atomic < ionic	atomic < ionic
B	atomic < ionic	atomic > ionic
C	atomic > ionic	atomic < ionic
D	atomic > ionic	atomic > ionic

---

459. 9701_m17_qp_12 Q: 12

The electrical conductivities of two compounds, Y and Z, are shown in the table.

	Y	Z
conductivity of the compound in the liquid state	good	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good

What could compounds Y and Z be?

	Y	Z
A	Al_2O_3	$SiCl_4$
B	NaF	Al_2O_3
C	NaF	$SiCl_4$
D	$SiCl_4$	Al_2O_3

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460. 9701_s17_qp_12 Q: 12

The elements magnesium and sulfur each form doubly charged ions.

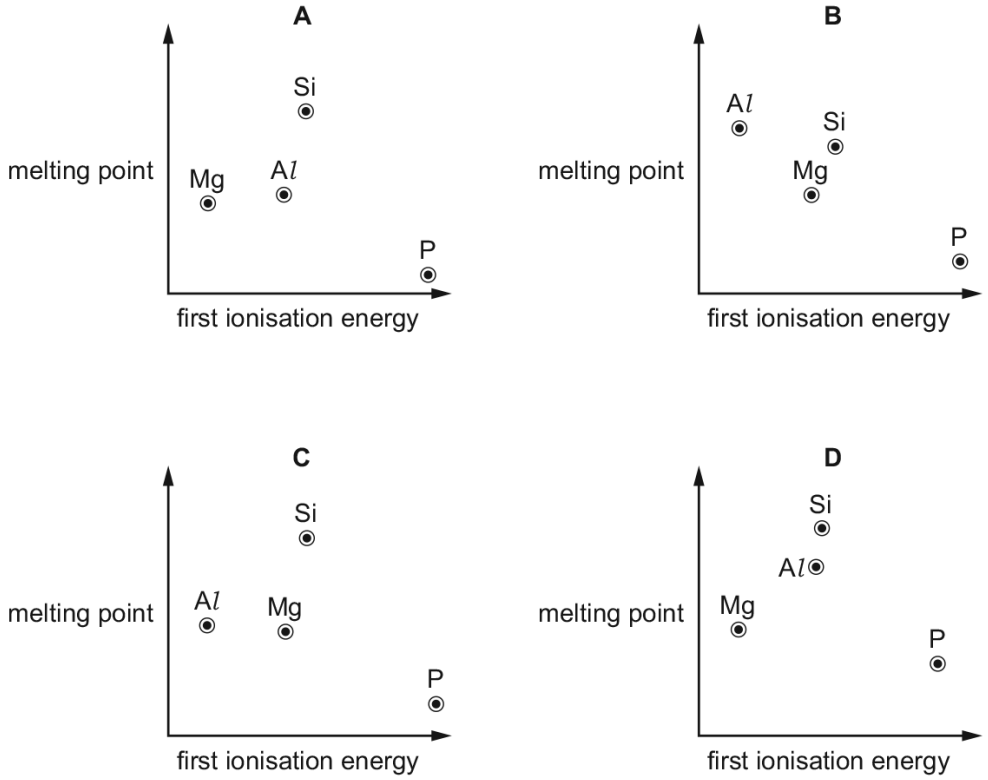
How do the atomic radii and ionic radii of these elements compare?

	atomic radius		ionic radius	atomic radius		ionic radius
A	Mg	>	Mg^{2+}	S	>	S^{2-}
B	Mg	>	Mg^{2+}	S	<	S^{2-}
C	Mg	<	Mg^{2+}	S	>	S^{2-}
D	Mg	<	Mg^{2+}	S	<	S^{2-}

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461. 9701_s17_qp_13 Q: 13

Which graph correctly shows the relative melting points of the elements Mg, Al, Si and P plotted against their relative first ionisation energies?



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462. 9701_w17_qp_11 Q: 12

The elements Cl, Mg, Si and S are all in Period 3.

What is the correct sequence of the melting points of these elements, from lowest to highest?

	lowest melting point	→		highest melting point
A	Cl	S	Mg	Si
B	Cl	S	Si	Mg
C	Mg	Si	S	Cl
D	Si	Mg	S	Cl

---

463. 9701_m16_qp_12 Q: 12

Consecutive elements **X**, **Y** and **Z** are in Period 3 of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of **X**, **Y** and **Z**?

A sodium, magnesium, aluminium

B magnesium, aluminium, silicon

C aluminium, silicon, phosphorus

D silicon, phosphorus, sulfur

---

464. 9701_s16_qp_11 Q: 12

Why is the ionic radius of a chloride ion larger than the ionic radius of a sodium ion?

A A chloride ion has one more occupied electron shell than a sodium ion.

B Chlorine has a higher proton number than sodium.

C Ionic radius increases regularly across the third period.

D Sodium is a metal, chlorine is a non-metal.

---

465. 9701_s16_qp_11 Q: 13

Elements D and E are both in Period 3. Element D has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element E. Elements D and E react together to form compound L.

Which compound could be L?

A $MgCl_2$ **B** MgS **C** Na_2S **D** PCl_3

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466. 9701_s16_qp_12 Q: 12

Sodium and sulfur react together to form sodium sulfide, Na_2S.

How do the atomic radius and ionic radius of sodium compare with those of sulfur?

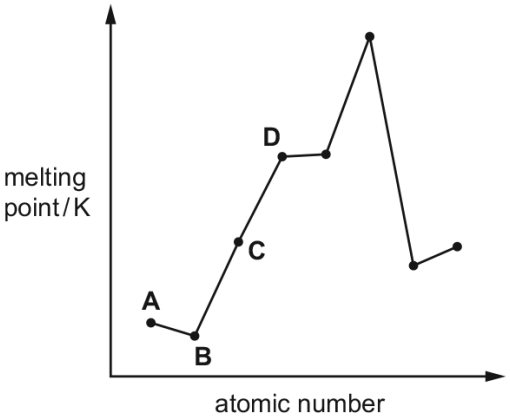
	atomic radius	ionic radius
A	sodium < sulfur	sodium > sulfur
B	sodium < sulfur	sodium < sulfur
C	sodium > sulfur	sodium > sulfur
D	sodium > sulfur	sodium < sulfur

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467. 9701_w16_qp_11 Q: 13

The diagram shows the melting points of eight elements with consecutive atomic numbers.

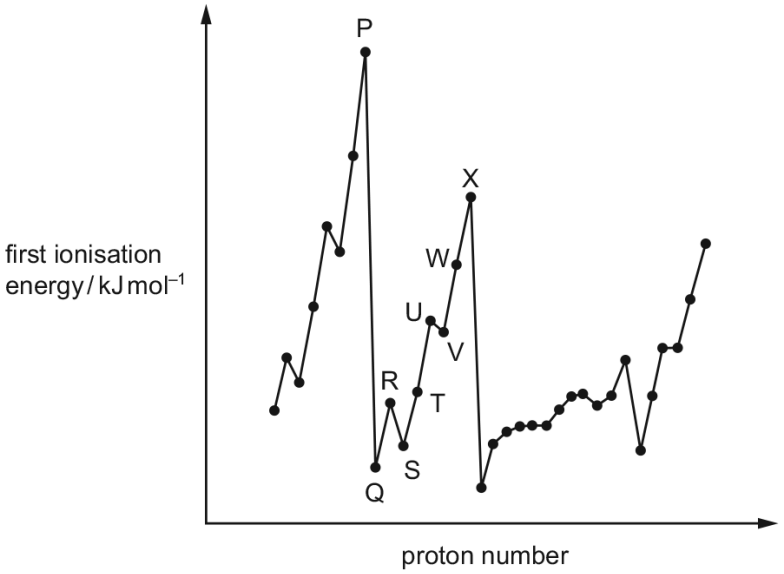
Which element could be sodium?



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468. 9701_w16_qp_12 Q: 12

The graph below shows the variation of the first ionisation energy with proton number for some elements. The letters used are not the usual symbols for the elements.



Which statement about the elements is correct?

A P and X are in the same period in the Periodic Table.

B The general increase from Q to X is due to increasing atomic radius.

C The small decrease from R to S is due to decreased shielding.

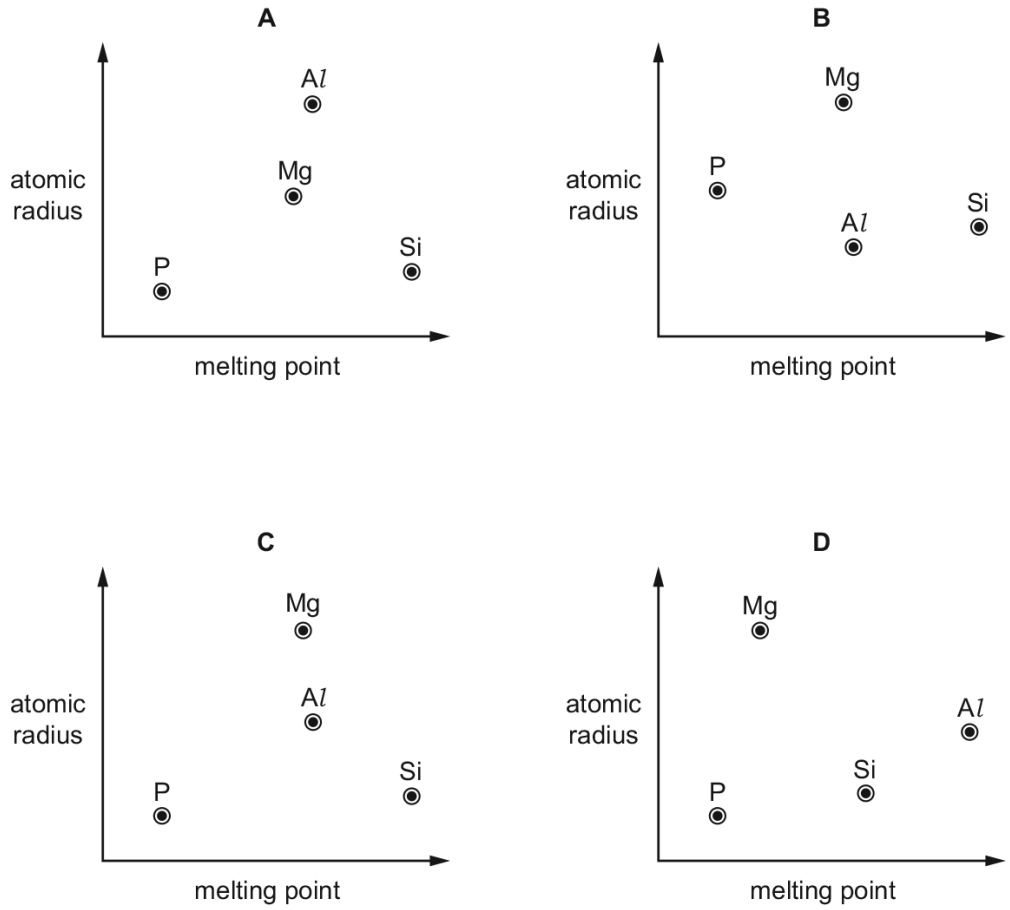
D The small decrease from U to V is due to repulsion between paired electrons.

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469. 9701_s15_qp_11 Q: 15

Use of the Data Booklet is relevant to this question.

Which diagram correctly shows the atomic radii of the elements Mg, A*l*, Si and P plotted against their melting points?



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470. 9701_s15_qp_13 Q: 17

This question refers to isolated gaseous species.

The species F^-, Ne and Na^+ are isoelectronic. This means they have the same number of electrons.

In which order do their radii increase?

	smallest ⟶		largest
A	Na^+	F^-	Ne
B	F^-	Ne	Na^+
C	Na^+	Ne	F^-
D	Ne	F^-	Na^+

---

471. 9701_w15_qp_11 Q: 14

Use of the Data Booklet is relevant to this question.

Which of the elements sodium, magnesium, aluminium, silicon, phosphorus, sulfur and chlorine

- has a lower first ionisation energy than the preceding element in the Periodic Table,
- conducts electricity and
- has a lower atomic radius than the preceding element in the Periodic Table?

A aluminium

B magnesium

C phosphorus

D sulfur

---

472. 9701_w15_qp_11 Q: 15

The melting points of the Period 3 elements sodium to aluminium are shown in the table.

element	Na	Mg	A*l*
mp/K	371	923	932

Which factor explains the **increase** in melting points from sodium to aluminium?

A the changes in first ionisation energy from sodium to aluminium

B the increase in electronegativity from sodium to aluminium

C the increase in the A_r of the elements from sodium to aluminium

D the increase in the number of outer electrons in each atom from sodium to aluminium

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473. 9701_w15_qp_12 Q: 15

Use of the Data Booklet is relevant to this question.

Which row correctly compares the electrical conductivity and first ionisation energy of magnesium and aluminium?

	higher electrical conductivity	higher first ionisation energy
A	aluminium	aluminium
B	aluminium	magnesium
C	magnesium	aluminium
D	magnesium	magnesium

9.2 Periodicity of chemical properties of the elements in Period 3

474. 9701_m22_qp_12 Q: 17

A student investigated the chloride of a Period 3 element. This is what the student wrote down as a record.

> The compound was a white crystalline solid. It dissolved easily in water to give a solution of pH 12. When placed in a test-tube and heated in a roaring Bunsen flame, the compound melted after several minutes heating.

What can be deduced from this record?

A At least one of the recorded observations is incorrect.

B The compound was magnesium chloride, $MgCl_2$.

C The compound was phosphorus pentachloride, PCl_5.

D The compound was sodium chloride, $NaCl$.

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475. 9701_m22_qp_12 Q: 18

The elements in Period 3 and their compounds show trends across the period from sodium to chlorine.

Which row is correct?

	electronegativity of the elements	acid / base behaviour of the oxides of the elements
A	decreases	basic → amphoteric → acidic
B	decreases	acidic → amphoteric → basic
C	increases	basic → amphoteric → acidic
D	increases	acidic → amphoteric → basic

---

476. 9701_m22_qp_12 Q: 19

The table shows the melting points of SiO_2 and P_4O_6.

oxide	SiO_2	P_4O_6
melting point / K	1883	297

Which statement explains the difference between the melting points of SiO_2 and P_4O_6?

A The bonding of the oxides changes from ionic to covalent.

B The metallic character of the elements decreases across Period 3.

C The oxidation number of the element increases from Si to P.

D The structure changes from giant molecular to simple molecular.

---

477. 9701_m21_qp_12 Q: 12

Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

A No visible change is observed.

B Steamy fumes and a precipitate are both observed.

C The appearance of a precipitate is the only observation.

D The appearance of steamy fumes is the only observation.

---

478. 9701_s21_qp_11 Q: 12

Element X is in Period 3. Element X forms a solid oxide Y.

Y reacts with hot concentrated hydrochloric acid. Y reacts with hot aqueous sodium hydroxide to form a compound in which X is part of an anion.

How many p electrons does one atom of X have in its outer shell?

A 0 **B** 1 **C** 2 **D** 3

---

479. 9701_s21_qp_11 Q: 19

R is an oxide of Period 3 element T. 5.00 g of R contains 2.50 g of T.

What is T?

A magnesium

B aluminium

C silicon

D sulfur

---

480. 9701_s21_qp_12 Q: 12

A sample of $SiCl_4$ is added to cold water.

Which statement describes the mixture formed at the end of the reaction?

A acidic solution with no precipitate

B acidic solution with white precipitate

C neutral solution with no precipitate

D neutral solution with white precipitate

---

481. 9701_s21_qp_12 Q: 13

L and M are elements in Period 3 of the Periodic Table.

- The oxide of L is a solid at room temperature. This oxide has a giant structure.
- The chloride of L does not react with water.
- Argon is the only element in Period 3 with a lower melting point than M.

Which formula represents a compound of elements L and M?

A Al_2S_3 **B** MgS **C** $NaCl$ **D** PCl_5

---

482. 9701_s21_qp_13 Q: 19

Two oxides of Period 3 elements are added separately to water. Both react to form colourless solutions. One solution is alkaline, the other is acidic.

What could be the two oxides?

A Al_2O_3 and SiO_2

B Al_2O_3 and P_4O_{10}

C Na_2O and P_4O_{10}

D Na_2O and SiO_2

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483. 9701_w21_qp_11 Q: 12

Which element requires the least number of moles of oxygen for the complete combustion of 1 mol of its atoms?

A aluminium

B magnesium

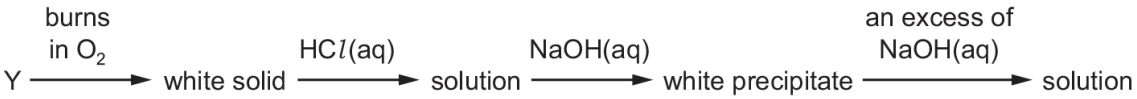
C phosphorus

D sodium

---

484. 9701_w21_qp_11 Q: 13

An element, Y, reacts according to the following sequence.



What could be element Y?

A Na **B** Mg **C** Al **D** P

---

485. 9701_w21_qp_12 Q: 12

A mixture of two Period 3 oxides are added to water. A solution forms with a pH of just below 7.

What could be the constituents of the mixture?

A Al_2O_3 and MgO

B Na_2O and MgO

C Na_2O and P_4O_{10}

D SO_3 and P_4O_{10}

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486. 9701_w21_qp_13 Q: 12

Which element requires the least number of moles of oxygen for the complete combustion of 1 mol of its atoms?

A aluminium

B magnesium

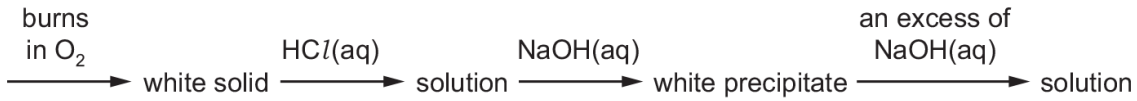
C phosphorus

D sodium

---

487. 9701_w21_qp_13 Q: 13

An element, Y, reacts according to the following sequence.



What could be element Y?

A Na **B** Mg **C** Al **D** P

---

488. 9701_m20_qp_12 Q: 12

X and Y are oxides of different Period 3 elements.

If one mole of X is added to water, the solution formed is neutralised by exactly one mole of Y.

What could be the identities of X and Y?

	X	Y
A	P_4O_{10}	Al_2O_3
B	SO_3	Al_2O_3
C	P_4O_{10}	Na_2O
D	SO_3	Na_2O

---

489. 9701_m20_qp_12 Q: 16

Solid ammonium nitrate is put into a test-tube and solution X is added to it. The resulting mixture is warmed and the gas given off is tested with damp red litmus paper. The litmus paper changes colour from red to blue.

What could be the identity of X and its role in the reaction?

	identity of X	role of X
A	NaOH(aq)	proton donor
B	NaOH(aq)	proton acceptor
C	HCl(aq)	proton donor
D	HCl(aq)	proton acceptor

---

490. 9701_s20_qp_11 Q: 15

Element Z has a giant structure.

The chloride of Z reacts with water to give a solution with a pH less than 5.

Which pair shows two elements which could be Z?

A aluminium, magnesium

B aluminium, silicon

C phosphorus, magnesium

D phosphorus, silicon

---

491. 9701_s20_qp_11 Q: 16

Sodium, aluminium and silicon are three elements in Period 3. Each element forms an oxide.

Which row has three correct properties of these oxides?

	sodium oxide	aluminium oxide	silicon dioxide
A	basic	basic	amphoteric
B	giant ionic	giant ionic	simple molecular
C	high melting point	low melting point	high melting point
D	reacts with water	no reaction with water	no reaction with water

---

492. 9701_s20_qp_12 Q: 16

One molecule of an oxide of element Z reacts with six molecules of water to produce an acidic compound.

What is element Z?

A aluminium

B phosphorus

C silicon

D sulfur

---

493. 9701_s20_qp_13 Q: 15

Which element, when burned in oxygen, can form an oxide that is a reducing agent?

A Na **B** Mg **C** Al **D** S

---

494. 9701_s20_qp_13 Q: 19

Element X is in Period 3. It reacts rapidly with water to form an alkaline solution.

Which statement about the **chloride** of element X is correct?

A It conducts electricity when molten.

B It has a melting point of less than 100 °C.

C It has covalent bonding.

D It reacts rapidly with cold water.

---

495. 9701_w20_qp_11 Q: 12

X and Y are two elements in Period 3 of the Periodic Table. They combine to form compound Z.

X forms a soluble acidic oxide. The oxidation number of X in this oxide is +4.

Y forms an amphoteric oxide.

What is the formula of compound Z?

A $Al P$ **B** Al_2S_3 **C** Si_2P_5 **D** SiS_2

---

496. 9701_w20_qp_11 Q: 19

Sulfur dioxide, SO_2, reacts with calcium hydroxide in aqueous solution.

What is the main product that is first formed?

A $Ca(HSO_4)_2$ **B** CaS **C** $CaSO_3$ **D** $CaSO_4$

---

497. 9701_w20_qp_12 Q: 12

Element X, in Period 3, has the following properties.

- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise $HCl(aq)$.

What is element X?

A Mg **B** Al **C** Si **D** P

---

498. 9701_w20_qp_12 Q: 19

Compound X is the oxide of a Period 3 element. Compound X reacts with water to give an acidic solution.

A solution is prepared by reacting 0.100 g of compound X with an excess of water. This solution is neutralised by exactly 25.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution.

What could be the identity of compound X?

A Al_2O_3 **B** MgO **C** P_4O_{10} **D** SO_3

---

499. 9701_m19_qp_12 Q: 12

X, Y and Z are elements in Period 3 of the Periodic Table. The results of some experiments carried out with compounds of these elements are shown.

element	result of adding the oxide of the element to $H_2O(l)$	result of adding the chloride of the element to $H_2O(l)$	result of adding the oxide of the element to $HCl(aq)$
X	no reaction	hydrolyses	forms chloride salt
Y	forms hydroxide	dissolves	forms chloride salt
Z	forms acid	hydrolyses	hydrolyses

Which statement could be correct?

A X is Al and Y is Mg.

B X is Si and Y is Na.

C Y is Al and Z is P.

D Y is Na and Z is Al.

---

500. 9701_m19_qp_12 Q: 13

A solid Period 3 element, Q, is reacted with oxygen gas. Compound R is formed.

When R is added to water the pH decreases.

What could be the empirical formula of R?

A Q_2O_4 **B** Q_2O_5 **C** Q_4O_{10} **D** Q_5O_2

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501. 9701_s19_qp_12 Q: 12

Element Q readily oxidises in air. The oxide produced reacts with water to form a solution of very low pH.

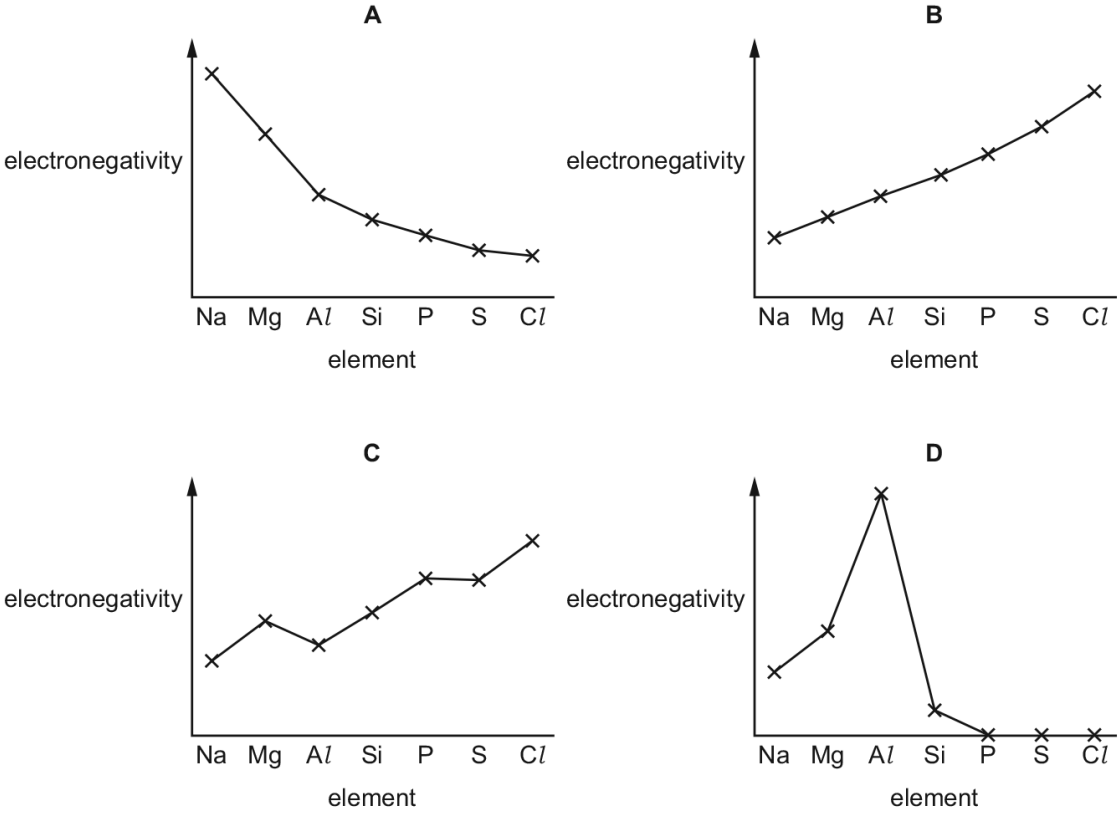
Where could element Q be found in the Periodic Table?

	period	group
A	2	1
B	2	14
C	3	14
D	3	15

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502. 9701_s19_qp_13 Q: 13

Which graph represents the variation in electronegativity for Period 3 elements?



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503. 9701_w19_qp_11 Q: 12

Which oxide will cause an increase in pH when added to water?

A MgO **B** Al_2O_3 **C** SiO_2 **D** SO_2

---

504. 9701_m18_qp_12 Q: 16

The volatility of the Group 17 elements, chlorine, bromine and iodine, decreases down the group.

What is responsible for this?

A bond length in the halogen molecule

B bond strength in the halogen molecule

C electronegativity of the halogen

D number of electrons in the halogen molecule

---

505. 9701_m18_qp_12 Q: 17

Bromine is extracted from sea-water.

In the final stages of the process two redox reactions take place.

$$Br_2(aq) + SO_2(g) + 2H_2O(l) \rightarrow 2HBr(aq) + H_2SO_4(aq)$$

$$2HBr(aq) + Cl_2(g) \rightarrow Br_2(g) + 2HCl(aq)$$

Which row is correct?

	strongest oxidising agent	⟶	weakest oxidising agent
A	Br_2	SO_2	Cl_2
B	Cl_2	Br_2	SO_2
C	Cl_2	SO_2	Br_2
D	SO_2	Br_2	Cl_2

---

506. 9701_m18_qp_12 Q: 18

When burned, sulfur forms a gaseous product X which can be oxidised to produce a gas Y.

Gas Y reacts with water to produce a product Z.

Which row correctly shows the oxidation states of sulfur in X, Y and Z?

	X	Y	Z
A	–2	+4	+4
B	–2	+4	+6
C	+4	+6	+4
D	+4	+6	+6

---

507. 9701_s18_qp_11 Q: 12

Silicon is heated in an excess of chlorine, producing compound J.

Excess water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

---

508. 9701_s18_qp_12 Q: 12

Which oxide does **not** react with cold, dilute sodium hydroxide to produce a salt?

A Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2

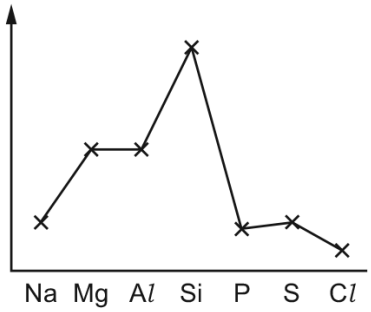
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509. 9701_s18_qp_12 Q: 13

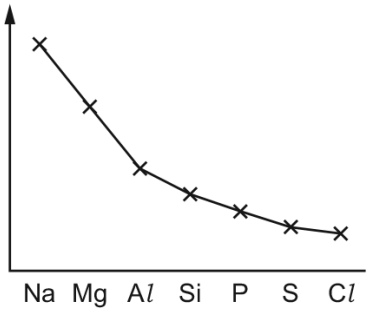
The graphs show trends in four physical properties of elements in Period 3, excluding argon.

Which graph has electronegativity on the *y*-axis?

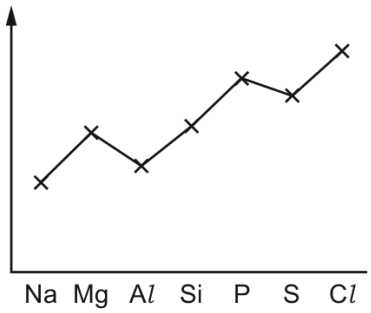
A



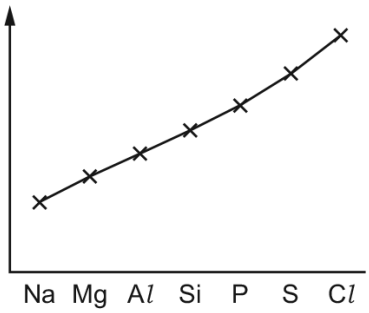
B



C



D



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510. 9701_s18_qp_13 Q: 12

Which description of the bonding and acid / base nature of aluminium oxide is correct?

	bonding	acid / base nature
A	simple covalent	amphoteric
B	giant covalent	basic only
C	ionic	amphoteric
D	ionic	basic only

---

511. 9701_s18_qp_13 Q: 13

X and Y are elements of the third period.

X and Y are individually heated in excess chlorine. Each product is purified and then separately added to water, producing two solutions. Both solutions have a pH of less than 5.

What could be X and Y?

A Na and P **B** Mg and Al **C** Mg and Si **D** Si and P

---

512. 9701_w18_qp_11 Q: 12

Sodium and sulfur are burned separately in oxygen.

Each reaction has a distinctive coloured flame.

Which row is correct?

	Na + O_2	S + O_2
A	white	blue
B	white	yellow
C	yellow	blue
D	yellow	yellow

---

513. 9701_w18_qp_11 Q: 13

X and Y are elements in Period 3 of the Periodic Table.

- The oxide of X is a solid at room temperature. This oxide has a giant structure.
- The chloride of X does not react with water.
- Argon is the only element in Period 3 with a lower melting point than Y.

What could be the formula of a compound formed between elements X and Y?

A Al_2S_3 **B** MgS **C** NaCl **D** PCl_5

---

514. 9701_w18_qp_12 Q: 12

The melting points of the Period 3 elements phosphorus to argon are shown in the table.

element	P	S	Cl	Ar
mp/K	317	392	172	84

Which factor explains the changes in melting points from phosphorus to argon?

A the changes in electronegativity from phosphorus to argon

B the changes in first ionisation energy from phosphorus to argon

C the increase in the number of electrons in each atom from phosphorus to argon

D the number of atoms in each molecule of the element from phosphorus to argon

---

515. 9701_w18_qp_12 Q: 13

Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

A No visible change is observed.

B Steamy fumes and a precipitate are both observed.

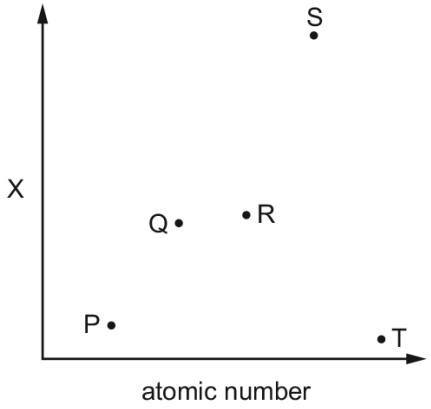
C The appearance of a precipitate is the only observation.

D The appearance of steamy fumes is the only observation.

---

516. 9701_m17_qp_12 Q: 15

The magnitude of property X of five elements from the third period of the Periodic Table, P, Q, R, S and T is shown. P, Q, R, S and T have consecutive atomic numbers. The letters do not represent the symbols of the elements.

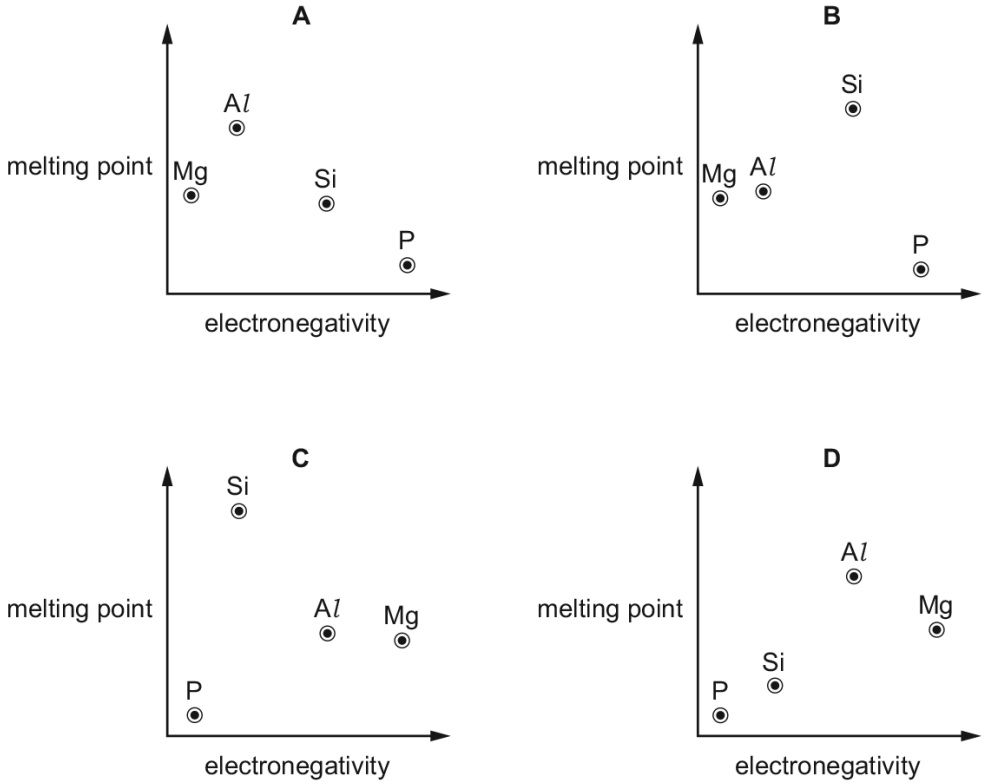


Which row correctly identifies property X and element R?

	property X	element R
A	electrical conductivity	A*l*
B	electronegativity	Si
C	melting point	A*l*
D	melting point	Si

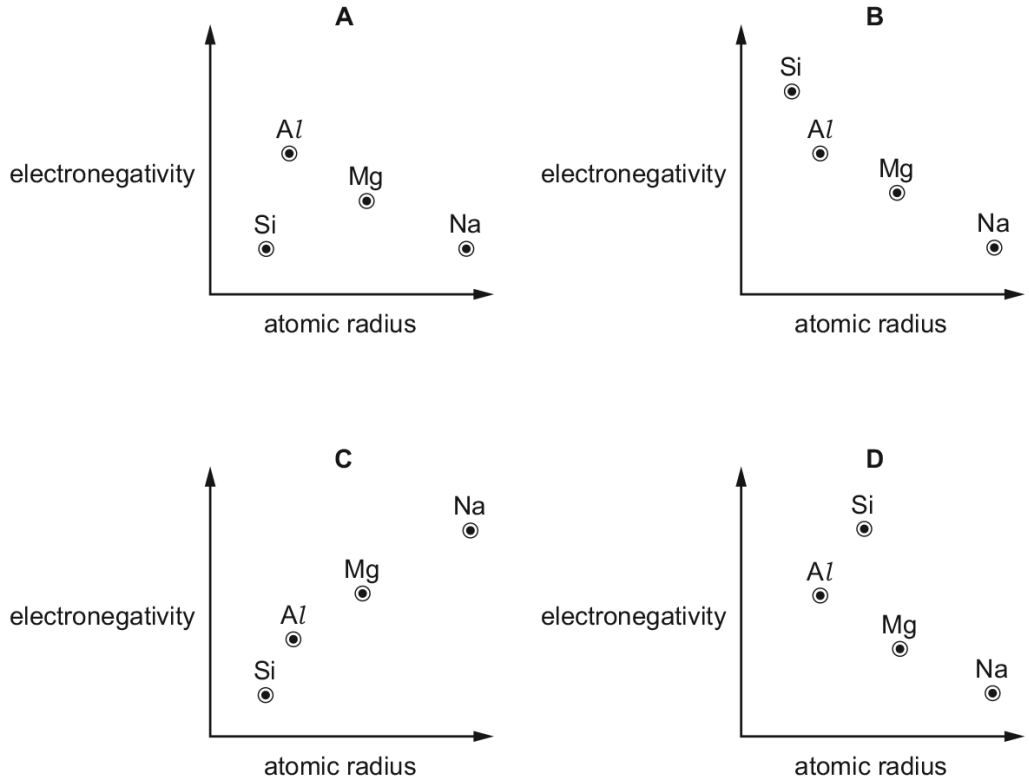
517. 9701_s17_qp_11 Q: 13

Which graph correctly shows the relative melting points of the elements Mg, Al, Si and P plotted against their relative electronegativities?



518. 9701_s17_qp_12 Q: 13

Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?



---

519. 9701_s17_qp_13 Q: 12

Magnesium chloride, $MgCl_2$, and silicon tetrachloride, $SiCl_4$, are separately added to water.

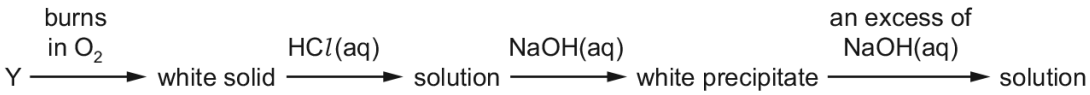
What are the approximate pH values of the solutions formed?

	$MgCl_2$	$SiCl_4$
A	0–3	0–3
B	0–3	6–7
C	6–7	0–3
D	6–7	6–7

---

520. 9701_w17_qp_11 Q: 13

An element Y reacts according to the following sequence.



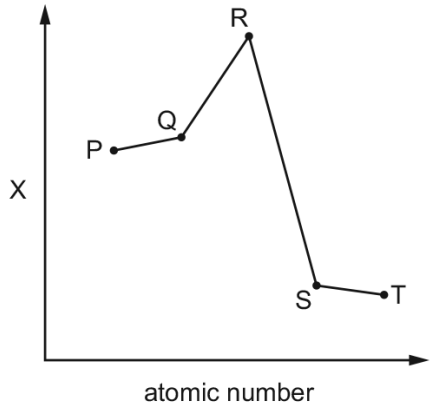
What could be element Y?

A Al **B** Ca **C** Mg **D** P

---

521. 9701_w17_qp_12 Q: 12

The relative magnitude of the property X of five elements is shown. P, Q, R, S and T are all in Period 3 and have consecutive atomic numbers.



Which row shows a correct pairing of property X and element R?

	property X	element R
A	electrical conductivity	Al
B	electronegativity	Si
C	melting point	Al
D	second ionisation energy	Si

---

522. 9701_w17_qp_12 Q: 13

Element Z has a giant structure.

The chloride of Z reacts with water to give a solution with a pH less than 5.

Which row shows two elements which could be Z?

A aluminium, magnesium

B aluminium, silicon

C phosphorus, magnesium

D phosphorus, silicon

---

523. 9701_m16_qp_12 Q: 13

When dealing with a spillage of metallic sodium it is important that no toxic or flammable products are formed.

Which material should be used if there is a spillage of metallic sodium?

A dilute hydrochloric acid

B ethanol

C sand

D water spray

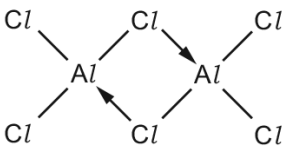
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524. 9701_s16_qp_12 Q: 13

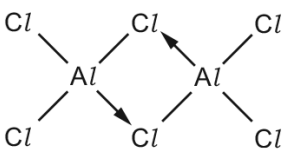
Solid aluminium chloride sublimes at 178 °C.

Which structure best represents the species in the vapour at this temperature?

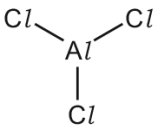
A



B



C



D

$Al^{3+}(Cl^{-})_3$

---

525. 9701_s16_qp_13 Q: 12

The oxide and chloride of an element **X** are separately mixed with water. The two resulting solutions have the same effect on litmus.

What could element **X** be?

A Al **B** Ca **C** Na **D** P

---

526. 9701_s16_qp_13 Q: 13

Each pair below consists of a sample of two separate elements. Each element is in its standard state at room temperature and pressure.

Which pair of elements has chemical bonds of the same type between their atoms?

A aluminium and phosphorus

B chlorine and argon

C magnesium and silicon

D sulfur and chlorine

---

527. 9701_w16_qp_12 Q: 14

Elements Y and Z are both in Period 3.

When the chloride of Y is added to water, it reacts and a solution of pH 2 is produced.

When the chloride of Z is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

A Both chlorides hydrolyse in water.

B Y is magnesium and Z is sodium.

C Y is phosphorus and Z is aluminium.

D Y is silicon and Z is sodium.

---

528. 9701_s15_qp_11 Q: 14

Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

A No visible changes are observed.

B Steamy fumes and a white precipitate are both observed.

C The appearance of a white precipitate is the only observation.

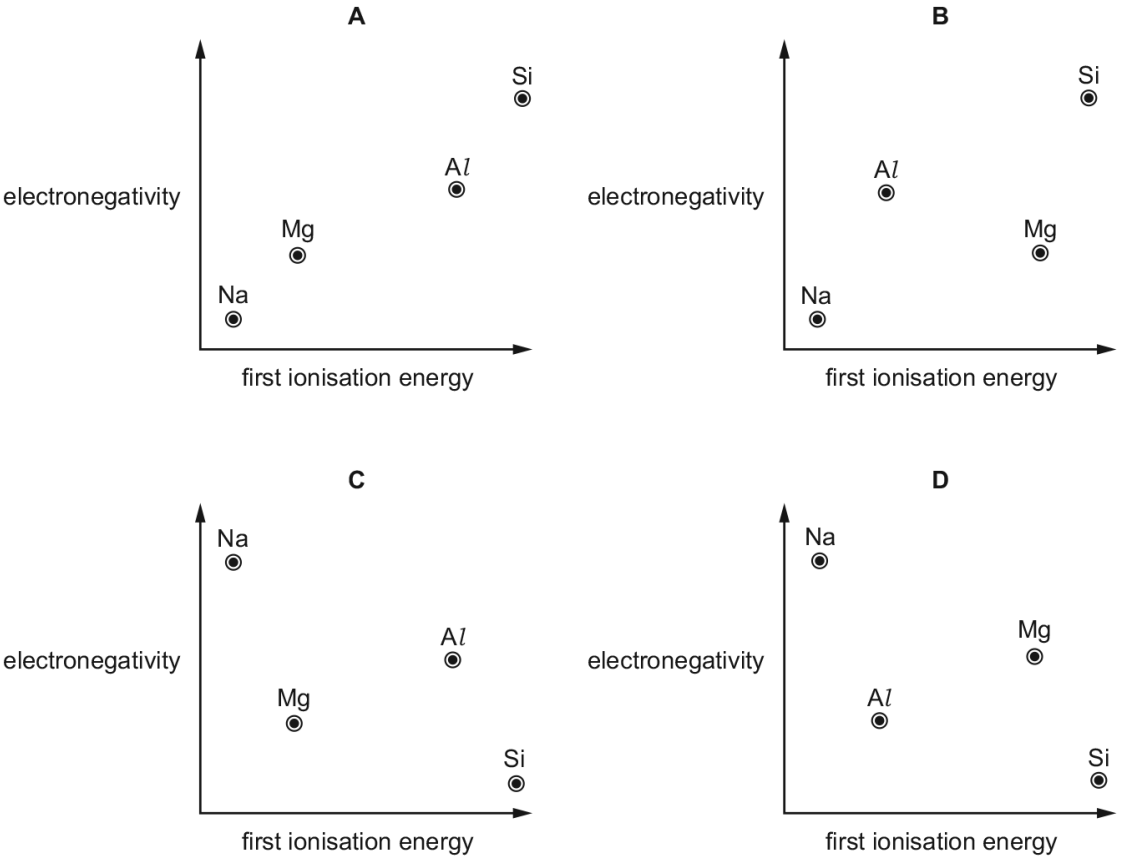
D The appearance of steamy fumes is the only observation.

---

529. 9701_s15_qp_12 Q: 15

Use of the Data Booklet is relevant to this question.

Which diagram correctly shows the electronegativity of the elements Na, Mg, Al and Si plotted against their first ionisation energies?



---

530. 9701_s15_qp_13 Q: 12

Which oxide will produce the solution with the highest pH when it is mixed with water?

A Al_2O_3 **B** CO_2 **C** Na_2O **D** SO_2

---

531. 9701_s15_qp_13 Q: 15

The labels had become detached from four bottles in the laboratory. A student realised that the contents of one of them could easily be identified, because on addition of water it would **not** give fumes of hydrogen chloride.

Which did **not** give the HCl fumes?

A Al_2Cl_6 **B** $MgCl_2$ **C** PCl_5 **D** $SiCl_4$

---

532. 9701_w15_qp_11 Q: 16

X is the oxide of a Period 3 element. **X** reacts with water to give an acidic solution.

A solution is prepared by reacting 0.100 g of **X** with excess water. This solution was neutralised by exactly 25.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution.

What could be the identity of **X**?

A Al_2O_3 **B** MgO **C** P_4O_{10} **D** SO_3

---

533. 9701_w15_qp_12 Q: 14

Which chloride of a Period 3 element dissolves in water to form a solution with a pH of 7?

A aluminium chloride

B phosphorus(V) chloride

C silicon(IV) chloride

D sodium chloride

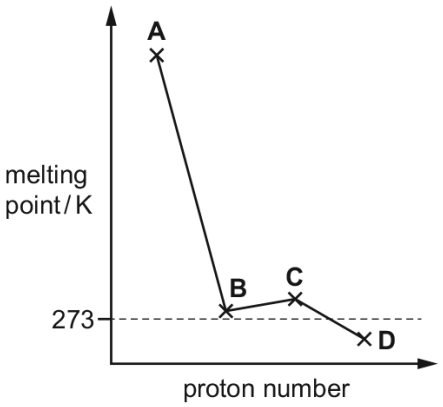
9.3 Chemical periodicity of other elements

534. 9701_s19_qp_11 Q: 13

The relative melting points of four consecutive elements in the Periodic Table are shown in the graph.

The elements all have proton numbers less than 20.

Which element is in Group 16?



---

535. 9701_s18_qp_11 Q: 10

Element X has a higher first ionisation energy than element Y.

Two students state what they believe is one factor that helps to explain this.

student 1 "X has a higher first ionisation energy than Y because an atom of X has more protons in its nucleus than an atom of Y."

student 2 "X has a higher first ionisation energy than Y because X has a smaller atomic radius than Y."

Only **one** of the two students is correct.

What could X and Y be?

	X	Y
A	carbon	boron
B	magnesium	aluminium
C	oxygen	nitrogen
D	oxygen	sulfur

---

536. 9701_s18_qp_11 Q: 13

Which element has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

A boron

B calcium

C magnesium

D sodium

Chapter 9

The Periodic Table: chemical periodicity

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9.1 Periodicity of physical properties of the elements in Period 3

36. 9701_s19_qp_21 Q: 2

Magnesium silicide, Mg_2Si, is a compound made by heating magnesium with sand.

(a) Draw a 'dot-and-cross' diagram to show the arrangement of outer electrons present in a formula unit of Mg_2Si. Assume magnesium silicide is an ionic compound.

[2]

(b) When solid Mg_2Si is added to water, silane gas, SiH_4, and a solution of magnesium hydroxide are produced.

Construct the equation for this reaction. Include state symbols.

..... [2]

(c) Suggest, with reference to structure and bonding, why SiH_4 is a gas at room temperature.

.....

.....

..... [2]

(d) The table shows the electronegativity values of carbon, hydrogen and silicon.

element	carbon	hydrogen	silicon
electronegativity	2.5	2.1	1.8

(i) C–H and Si–H bonds have weak dipoles.

Use the electronegativity values in the table to show the polarity of the C–H and Si–H bonds.

C—H Si—H

[2]

(ii) Explain why methane, CH_4, has no overall dipole moment.

.....

.....

..... [2]

(e) SiH_4 reacts in air without heating but CH_4 must be ignited before combustion occurs.

$$SiH_4 + 2O_2 \rightarrow SiO_2 + 2H_2O$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Suggest, with reference to bond energies from the *Data Booklet*, why SiH_4 reacts in air without heating but CH_4 must be ignited.

.....

.....

..... [2]

(f) Silicon dioxide reacts with hot, concentrated sodium hydroxide.

(i) Identify the **two** products formed during this reaction.

.....

..... [2]

(ii) Describe the behaviour of the silicon dioxide during this reaction.

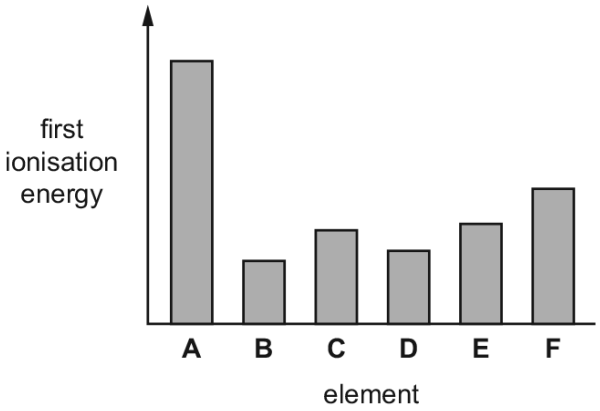
..... [1]

[Total: 15]

37. 9701_m18_qp_22 Q: 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*.

.....

.....

.....

..... [3]

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

.....

.....

.....

.....

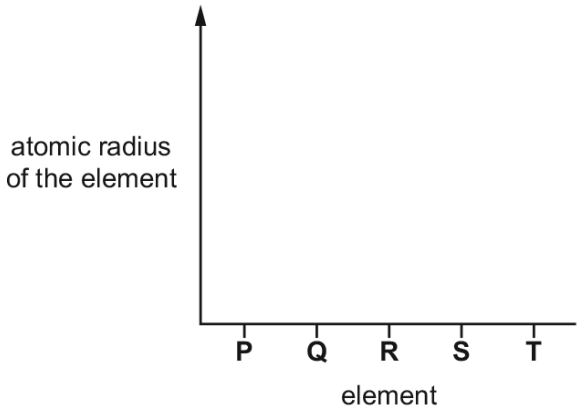
..... [3]

(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 .....

.....

.....

.....

.....

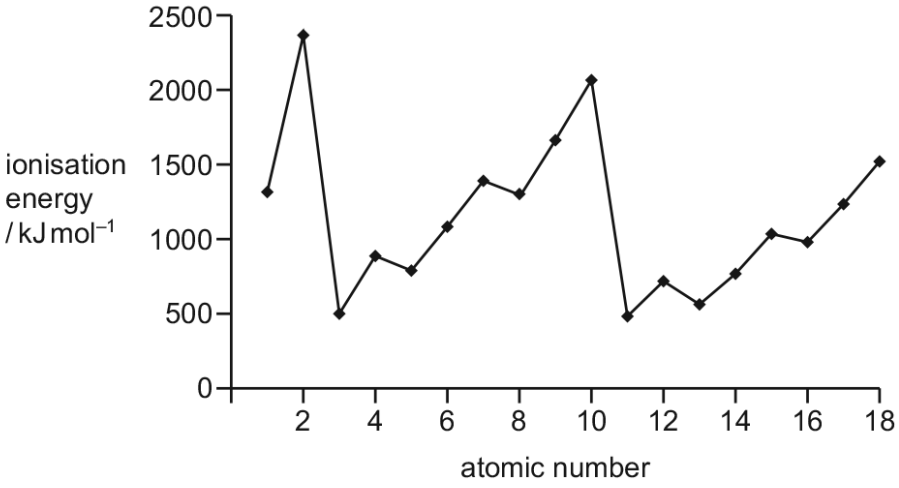
[3]

[Total: 9]

38. 9701_w16_qp_22 Q: 3

The Periodic Table is arranged such that the properties of the elements show a number of trends.

(a) A plot of the first ionisation energies for the first 18 elements is shown.



(i) Explain why the values show a general increase from atomic number 11 to 18.

.....

.....

..... [2]

(ii) Explain the decreases in first ionisation energies between

- atomic numbers 12 and 13,

.....

.....

.....

- atomic numbers 15 and 16.

.....

.....

.....

[4]

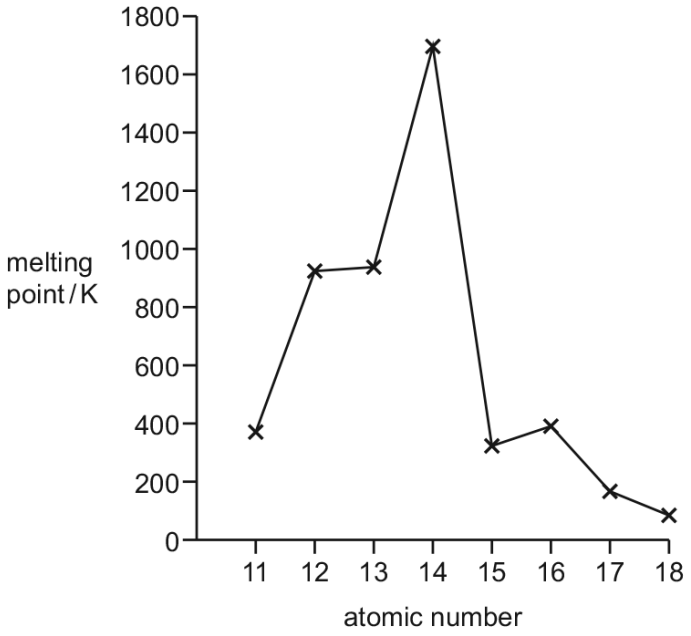
(iii) Suggest an explanation for the trend in the first ionisation energies of the elements with atomic numbers 2, 10 and 18.

.....

.....

..... [2]

(b) A plot of the melting points of the elements across the third period is shown.



(i) Explain the increase in melting point from atomic number 11 to 12.

.....

.....

..... [2]

(ii) Suggest a reason why the increase from atomic number 12 to 13 is much smaller than the increase from atomic number 11 to 12.

.....

..... [1]

(iii) State and explain the pattern of the melting points from atomic number 15 to 18.

.....

.....

.....

..... [3]

(iv) Explain why the element with atomic number 14 has a melting point so much higher than the rest of the elements in the third period.

.....

..... [1]

[Total: 15]

39. 9701_S15_qp_22 Q: 1

(a) Chemists recognise that atoms are made of three types of particle.

Complete the following table with their names and properties.

name of particle	relative mass	relative charge
		+1
	1/1836	

[3]

(b) Most elements exist naturally as a mixture of isotopes, each with their own relative isotopic mass. The mass spectrum of an element reveals the abundances of these isotopes, which can be used to calculate the relative atomic mass of the element.

Magnesium has three stable isotopes. Information about two of these isotopes is given.

isotope	relative isotopic mass	percentage abundance
^{24}Mg	24.0	79.0
^{26}Mg	26.0	11.0

(i) Define the term *relative isotopic mass*.

.....

.....

..... [2]

(ii) The relative atomic mass of magnesium is 24.3.

Calculate the percentage abundance and hence the relative isotopic mass of the third isotope of magnesium. Give your answer to **three** significant figures

percentage abundance = ...

isotopic mass = ...

[3]

(c) Magnesium can be produced by electrolysis of magnesium chloride in a molten mixture of salts.

(i) Give equations for the anode and cathode reactions during the electrolysis of molten magnesium chloride, $MgCl_2$.

anode .....

cathode .....

[2]

The electrolysis is carried out under an atmosphere of hydrogen chloride gas to convert any magnesium oxide impurity into magnesium chloride.

(ii) An investigation of the reaction between magnesium oxide and hydrogen chloride gas showed that an intermediate product was formed with the composition by mass Mg, 31.65%; O, 20.84%; H, 1.31% and Cl, 46.20%.

Calculate the empirical formula of this intermediate compound.

empirical formula ..... [2]

(d) The acid/base behaviour of the oxides in the third period varies across the period.

(i) Describe this behaviour and explain it with reference to the structure and bonding of sodium oxide, Na_2O, aluminium oxide, Al_2O_3, and sulfur trioxide, SO_3.

.....

.....

..... [2]

(ii) Write equations for reactions of these three oxides with hydrochloric acid and/or sodium hydroxide as appropriate.

.....

.....

.....

..... [4]

[Total: 18]

9.2 Periodicity of chemical properties of the elements in Period 3

40. 9701_s20_qp_21 Q: 1

Gallium is a metal in Group 13 of the Periodic Table.

(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]

(ii) State what further information is needed to calculate the relative atomic mass of gallium.

..... [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]

(ii) The table gives the formula of each gallium-containing product formed when gallium oxide reacts separately with hot aqueous hydrochloric acid and hot aqueous sodium hydroxide.

	formula of gallium-containing product
hot aqueous hydrochloric acid	$GaCl_3$
hot aqueous sodium hydroxide	$NaGa(OH)_4$

Give the name of the type of behaviour shown by gallium oxide in these reactions.

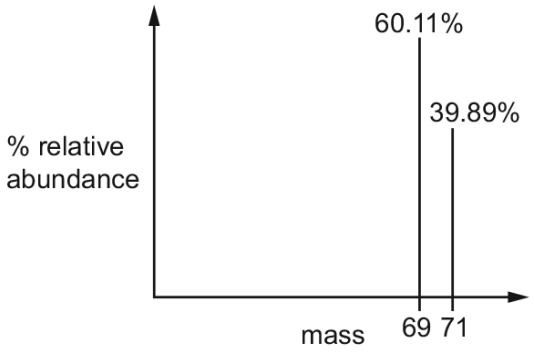
..... [1]

[Total: 8]

41. 9701_s20_qp_22 Q: 1

Gallium is an element in Group 13.

A sample of gallium is analysed using a mass spectrometer. The mass spectrum produced is shown.



(a) Explain what is meant by the term *relative atomic mass*.

.....

..... [2]

(b) Calculate the relative atomic mass of gallium in this sample. Give your answer to 4 significant figures.

Show your working.

relative atomic mass = ... [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]

(d) When gallium is heated in excess chlorine, gallium trichloride, $GaCl_3$, is made.

Draw the shape of the gallium trichloride molecule and suggest the Cl–Ga–Cl bond angle.

shape of molecule

bond angle .....

[2]

(e) Gallium oxide, Ga_2O_3, and aluminium oxide react in the same way with HCl(aq) and with NaOH(aq).

(i) Suggest the equation for the reaction between Ga_2O_3 and HCl(aq).

..... [1]

(ii) Suggest an equation for the reaction between gallium oxide and NaOH(aq).

..... [2]

[Total: 12]

42. 9701_w19_qp_21 Q: 2

(a) Complete the table to give details of the type of bonding and structure shown by some of the oxides of Period 3 elements.

	Na_2O	MgO	Al_2O_3	SiO_2	SO_3
boiling point/°C	1275	3670	2977	2950	45
nature of oxide	basic	basic	amphoteric	acidic	acidic
bonding					
structure					

[2]

(b) (i) Explain why the boiling point of SiO_2 is much higher than the boiling point of SO_3.

.....

.....

.....

..... [3]

(ii) Al_2O_3 is an amphoteric oxide.

Explain what is meant by the term *amphoteric*. Use chemical equations to illustrate your answer.

.....

.....

..... [3]

(iii) State what you would observe when a small sample of Na_2O is placed in water.

..... [1]

(c) Selenium is a Group 16 element which shows similar chemical reactions to sulfur.

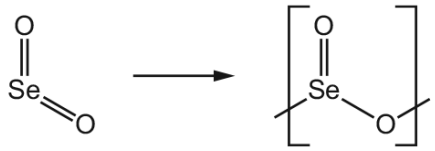
(i) Selenium reacts with fluorine to form SeF_6 molecules.

Predict the shape of a molecule of SeF_6.

..... [1]

(ii) The most stable oxide of selenium is SeO_2.

Gaseous SeO_2 reacts to form a solid polymer, as shown. In the reaction one Se=O is replaced by two Se–O to form a polymer.



$\Delta H = -346\,kJ\,mol^{-1}$

The bond enthalpy of Se=O is $514\,kJ\,mol^{-1}$.

Use these data to calculate the bond enthalpy, in $kJ\,mol^{-1}$, of Se–O.

bond enthalpy of Se–O = ... $kJ\,mol^{-1}$
[2]

(iii) SeO_2 shows similar chemical reactions to SO_2.

Suggest an equation to show the reaction of SeO_2 with aqueous sodium hydroxide, NaOH.

..... [1]

[Total: 13]

43. 9701_w19_qp_22 Q: 2

Oxygen is the most abundant element in the Earth's crust. It reacts with other elements to form stable compounds, ions and molecules.

(a) Complete the table to give the formulae and acid/base behaviour of some of the oxides of the Period 3 elements.

element	sodium	aluminium	silicon	phosphorus	sulfur
formula of oxide	Na_2O				SO_3
acid/base behaviour		amphoteric			

[2]

(b) Group 2 elements form stable hydroxides, with general formula $M(OH)_2$, where M is the Group 2 element.

(i) Beryllium hydroxide, $Be(OH)_2$, is an amphoteric compound that shows similar chemical reactions to aluminium oxide.

State the meaning of the term *amphoteric*.

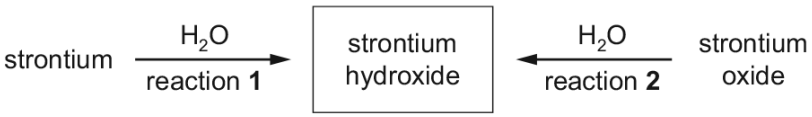
.....

..... [1]

(ii) Write an **ionic** equation for the reaction of magnesium hydroxide, $Mg(OH)_2$, with hydrochloric acid.

..... [1]

(iii) Two methods of preparing strontium hydroxide are shown.



State **one** difference between the observations you would make for reaction **1** and reaction **2**.

.....

.....

..... [1]

(iv) State how the solubility of the Group 2 hydroxides changes down the group.

..... [1]

(c) Sodium peroxide, Na_2O_2, reacts with CO_2.

$$Na_2O_2(s) + CO_2(g) \rightarrow Na_2CO_3(s) + \tfrac{1}{2}O_2(g)$$

The partial pressure of $CO_2(g)$ in a 0.500 dm^3 sample of air is 5.37 kPa at 20 °C.

(i) Calculate the amount, in moles, of $CO_2(g)$ present in the sample of air at 20 °C.

amount of $CO_2(g)$ = ... mol [2]

(ii) Calculate the mass of $Na_2O_2(s)$ that would react fully with the amount of $CO_2(g)$ calculated in **(i)**.

mass of $Na_2O_2(s)$ = ... g [1]

(iii) The peroxide ion, O_2^{2-}, has a single covalent bond between the two oxygen atoms. Each oxygen atom carries a negative charge.

Draw a 'dot-and-cross' diagram for the peroxide ion. Show outer electrons only.

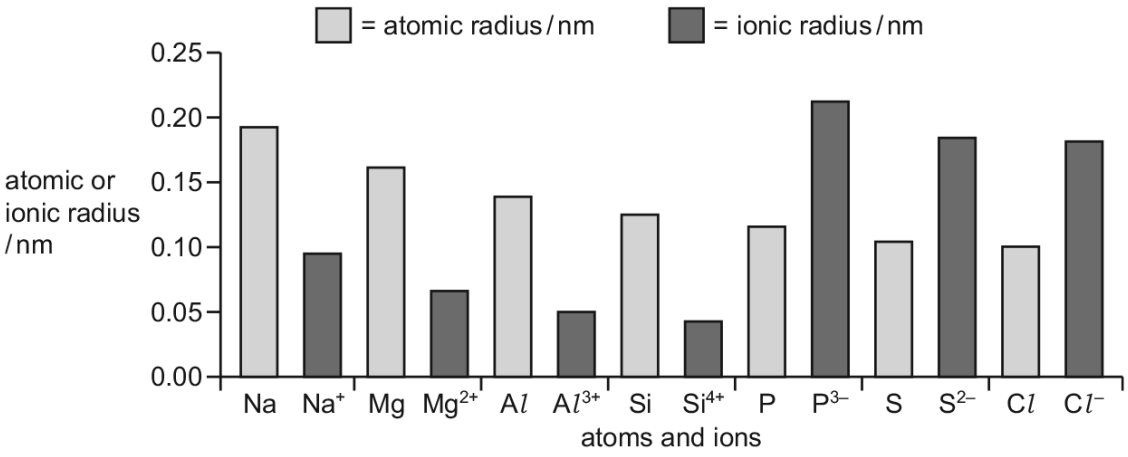
[2]

[Total: 11]

44. 9701_s18_qp_21 Q: 3

The elements in the third period exhibit periodicity in both their chemical and physical properties.

(a) A graph of the atomic and ionic radii across the third period is shown.



(i) Explain the decrease in atomic radius across the third period.

.....

.....

.....

..... [2]

(ii) Explain why, for sodium to silicon, the ionic radii are less than the atomic radii.

.....

..... [1]

(iii) Explain why, for phosphorus to chlorine, the ionic radii are greater than the atomic radii.

.....

.....

..... [2]

(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]

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

.....

.....

..... [2]

(c) The elements in the third period, from sodium to silicon, can react with chlorine to form chlorides.

(i) State and explain the pattern of change of oxidation number which occurs to both chlorine and the different Period 3 elements when they react together.

.....

.....

.....

..... [3]

(ii) Give the equations to show the reactions of sodium chloride and silicon(IV) chloride when separately added to water.

sodium chloride .....

silicon(IV) chloride .....
[2]

(iii) Complete the table to describe the structure and bonding in sodium chloride and silicon(IV) chloride.

	structure	bonding
sodium chloride		
silicon(IV) chloride		

[2]

[Total: 16]

45. 9701_m17_qp_22 Q: 1

(a) The table shows information about some of the elements in the third period.

element	Na	Mg	A*l*	P	S	C*l*
atomic radius / nm	0.186	0.160	0.143	0.110	0.104	0.099
radius of most common ion / nm	0.095	0.065	0.050	0.212	0.184	0.181
maximum oxidation number of the element in its compounds	+1					+7

(i) Complete the table to show the maximum oxidation number of each element in its compounds. [1]

(ii) Explain why the atomic radius of elements in the third period decreases from Na to C*l*.

.....

.....

.....

.....

..... [3]

(iii) The radius of the most common ion of Mg is much smaller than the radius of the most common ion of S.

Identify both ions and explain the difference in their radii.

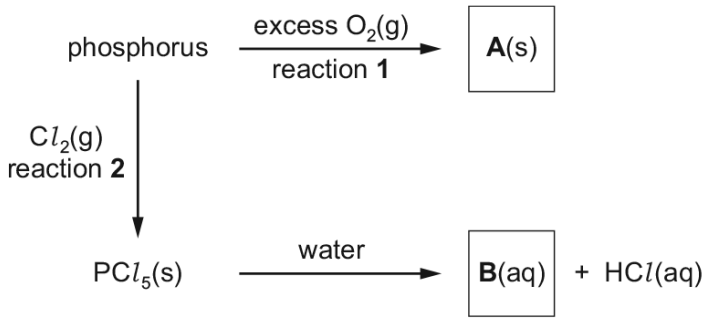
.....

.....

..... [2]

(b) Phosphorus is a non-metal in the third period. It reacts vigorously with excess oxygen but slowly with chlorine.

Some reactions of phosphorus are shown.



(i) Write an equation to represent reaction **1**, the formation of compound **A**.

..... [1]

(ii) Give **two** observations you could make in reaction **2**.

1. .....

2. .....

[2]

(iii) Name compound **B**.

..... [1]

(c) Cerium is a lanthanoid metal that shows similar chemical reactions to some elements in the third period. Most of cerium's compounds contain Ce^{3+} or Ce^{4+} ions.

(i) Cerium shows the same structure and bonding as a typical metal.

Draw a labelled diagram to show the structure and bonding in cerium.

[2]

(ii) Cerium(IV) oxide, CeO_2, is a ceramic.

Suggest **two** physical properties of cerium(IV) oxide.

1. .....

2. .....

[2]

(iii) A naturally occurring sample of cerium contains only **four** isotopes. Data for **three** of the isotopes are shown in the table.

isotope	^{136}Ce	^{138}Ce	^{140}Ce	^{142}Ce
relative isotopic mass	135.907	137.906	139.905	to be calculated
percentage abundance	0.185	0.251	88.450	to be calculated

The A_r of the sample is 140.116.

Use these data to calculate the **relative isotopic mass** of the fourth isotope in this sample of cerium.

Give your answer to **three** decimal places.

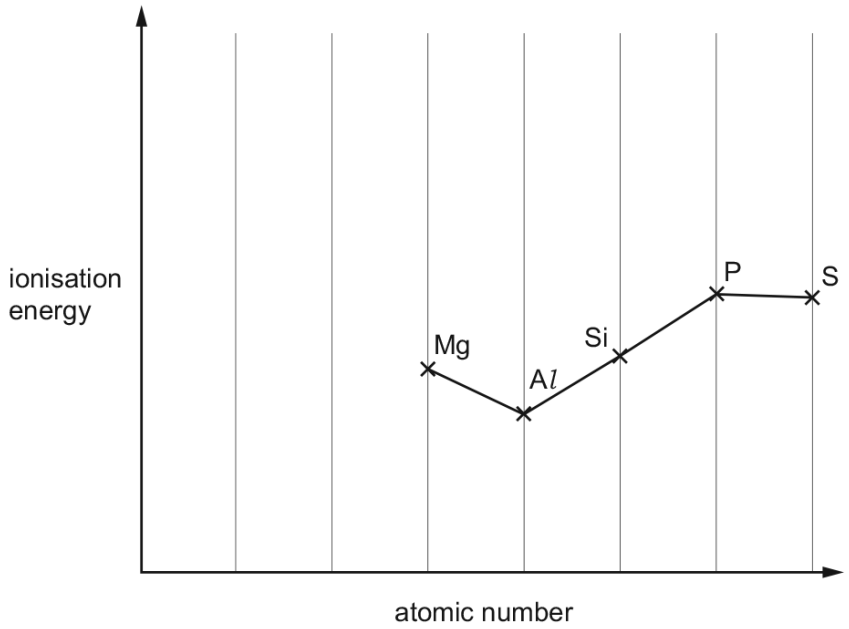
relative isotopic mass = ... [3]

[Total: 17]

46. 9701_w17_qp_21 Q: 2

The elements in the third period, and their compounds, show trends in their physical and chemical properties.

(a) A sketch graph of the first ionisation energies of five successive elements in the third period is shown.



(i) Explain why there is a general increase in the first ionisation energy across the third period.

.....

.....

..... [2]

(ii) Sketch, on the graph, the position of the ionisation energies of the two elements that come before Mg in this sequence. [2]

(iii) Explain, with reference to electron arrangements, the decreases in first ionisation energy between Mg and Al and between P and S.

Mg and Al .....

.....

.....

P and S .....

.....

.....
[4]

(b) The chlorides of the elements in the third period behave in different ways when added to water, depending on their structure and bonding.

L and **M** are each a chloride of an element in Period 3. A student investigated **L** and **M** and their results are given.

L is a white crystalline solid with a melting point of 987 K. **L** dissolves in water to form an approximately neutral solution. Addition of NaOH(aq) to an aqueous solution of **L** produces a white precipitate.

M is a liquid with a boiling point of 331 K. **M** is hydrolysed rapidly by cold water to form a strongly acidic solution, a white solid and white fumes.

Identify **L** and **M**.
Explain any properties and observations described.
Give equations where appropriate.

(i) **L** is .....

.....

.....

.....

..... [3]

(ii) **M** is .....

.....

.....

.....

..... [3]

[Total: 14]

47. 9701_w15_qp_21 Q: 1

Aluminium is a metal in Period 3 and Group III of the Periodic Table.

(a) Describe the structure of solid aluminium.

.....

.....

..... [2]

(b) A common use of aluminium is to make the conducting cables in long distance overhead power lines.

(i) Suggest two properties of aluminium that make it suitable for this use.

.....

.....

..... [2]

The cables are attached to pylons by ceramic supports.

(ii) Describe the structure of a ceramic material.

.....

..... [1]

(iii) State the property of a ceramic material that makes it suitable for this use.

.....

..... [1]

(c) Aluminium reacts with chlorine to form a white, solid chloride that contains 79.7% chlorine and sublimes (changes straight from a solid to a gas) at 180 °C.

(i) Describe the structure and bonding in this compound. Suggest how it explains the low sublimation temperature.

.....

.....

.....

.....

..... [2]

(ii) Calculate the empirical formula of the chloride. You must show your working.

empirical formula = ... [2]

At 200 °C and 100 kPa, a 1.36 g sample of this chloride occupied a volume of 200 cm^3.

(iii) Calculate the relative molecular mass, M_r, of the chloride. Give your answer to **three** significant figures.

M_r = ... [2]

(iv) Deduce the molecular formula of this chloride at 200 °C.

..... [1]

[Total: 13]

9.3 Chemical periodicity of other elements

48. 9701_s21_qp_23 Q: 3

Separate samples of **R**, **S**, **T** and **U** are added to cold water. The identity of each sample is unknown. However, each sample is known to be pure and can only be one of $Ba(OH)_2$, $NaCl$, P_4O_{10} or $SiCl_4$.

(a) (i) Use the observations in the table to identify each sample as one of $Ba(OH)_2$, $NaCl$, P_4O_{10} and $SiCl_4$. Write your answers in the table.

	state at room temperature	observations on addition of sample to water	identity of sample
R	solid	alkaline, colourless solution is produced, some white solid remains	
S	solid	white solid disappears, solution is neutral	
T	liquid	misty fumes produced, white solid is made in vigorous reaction	
U	solid	acidic, colourless solution produced in vigorous reaction	

[4]

(ii) Identify the formula of the white solid made when sample **T** reacts with water.

..... [1]

(iii) Name the solution formed when sample **U** reacts with water.

..... [1]

(b) Magnesium oxide and aluminium oxide have properties typical of ceramic materials.

(i) Name **one** physical property typical of ceramic materials.

..... [1]

(ii) Give the formula of another Period 3 oxide which behaves as a ceramic material.

..... [1]

(c) Tungsten oxide, W_xO_y, is used to give colour to ceramic materials.

A sample of W_xO_y contains 79.29% tungsten by mass.

Calculate the empirical formula of W_xO_y.

Show your working.

empirical formula = ...
[3]

[Total: 11]

---

49. 9701_w21_qp_22 Q: 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.

.....

.....

.....

.....

..... [2]

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

.....

.....

.....

.....

..... [2]

(iv) Complete the row in the table labelled 'maximum oxidation number'. [1]

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

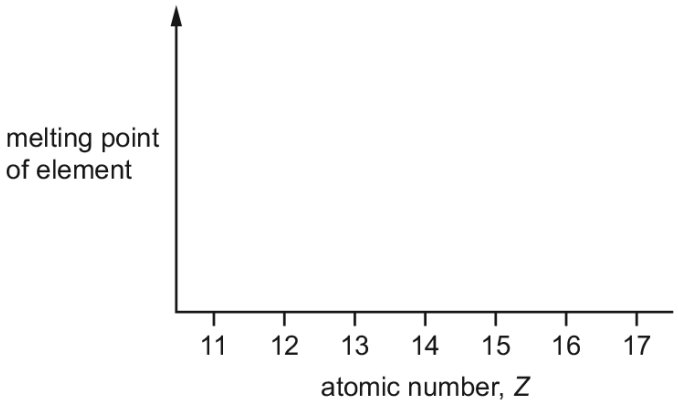
.....

.....

.....

..... [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, $_{31}$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
$_{5}$B	2.34	3930	0.020
$_{13}$A*l*		2470	0.050
$_{31}$Ga	5.91	2400	
$_{49}$In	7.30		0.081
$_{81}$T*l*	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 $In_2Br_6(g)$.

[2]

[Total: 17]

---

50. 9701_s16_qp_21 Q: 2

D, **E**, **F**, and **G** are four consecutive elements in the **fourth** period of the Periodic Table. (The letters are **not** the actual symbols of the elements.)

D is a soft, silvery metal with a melting point just above room temperature. Its amphoteric oxide, $\mathbf{D}_2O_3$, has a melting point of 1900 °C and can be formed by heating **D** in oxygen.

G is a solid that can exist as several different allotropes, most of which contain $\mathbf{G}_8$ molecules. **G** burns in air to form $\mathbf{G}O_2$ which dissolves in water to form an acidic solution. This solution reacts with sodium hydroxide to form the salt $Na_2\mathbf{G}O_3$.

(a) Suggest the identities of **D** and **G**.

D ..... **G** .....
[1]

(b) Write equations for the reactions of $\mathbf{D}_2O_3$ with

(i) hydrochloric acid,

..... [2]

(ii) sodium hydroxide.

..... [2]

(c) Suggest the type of bonding and structure in $\mathbf{D}_2O_3$.

..... [1]

(d) Write an equation for the formation of an acidic solution when $\mathbf{G}O_2$ dissolves in water.

..... [1]

[Total: 7]

1.

Which species represented by the following formulae has the largest radius?

A P^{3} **B** Cl **C** Ar **D** K^{1}

[2002 M/J (12)]

2.

Which of the following oxides is **unlikely** to dissolve in aqueous sodium hydroxide?

A Al_2O_3 **B** MgO **C** SO_2 **D** SiO_2

[2002 M/J (13)]

3.

An element of the third period (Na to S) is heated in chlorine. The product is purified and then added to water. The resulting solution is found to be neutral.

What is the element?

A sodium

B aluminium

C silicon

D phosphorus

[2002 M/J (14)]

4.

The chloride of element **Q** is hydrolysed by water to form an acidic solution and its oxide reacts with acid to form a salt.

What could be the element **Q**?

A magnesium

B aluminium

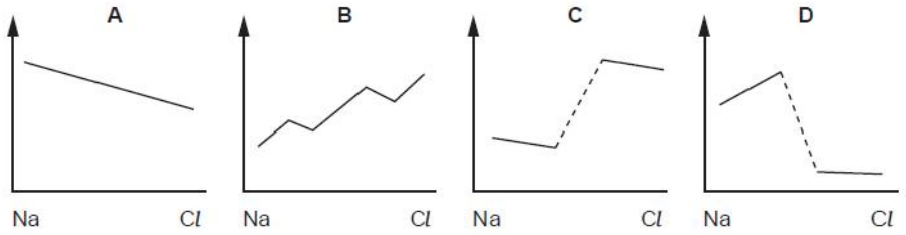
C silicon

D phosphorus

[2002 O/N (13)]

5.

Which diagram represents the change in ionic radius of the elements across the third period (Na to Cl)?



[2002 O/N (14)]

6.

Which isotope of an element in the third period of the Periodic Table contains the same number of neutrons as $^{32}_{16}S$?

A $^{23}_{11}Na$

B $^{24}_{12}Mg$

C $^{28}_{14}Si$

D $^{31}_{15}P$

[2003 M/J (3)]

7.

The successive ionisation energies, in $kJ\,mol^{-1}$, of an element **X** are given below.

870 1800 3000 3600 5800 7000 13200

What is **X**?

A $_{33}As$ **B** $_{40}Zr$ **C** $_{52}Te$ **D** $_{53}I$

[2003 M/J (4)]

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8.

A mixture of the oxides of two elements of the third period is dissolved in water. The solution is approximately neutral.

What could be the constituents of the mixture?

A Al_2O_3 and MgO

B Na_2O and MgO

C Na_2O and P_4O_{10}

D SO_3 and P_4O_{10}

[2003 M/J (13)]

9.

Aluminium chloride catalyses certain reactions by forming carbocations (carbonium ions) with chloroalkanes as shown.

$$RCl + AlCl_3 \rightarrow R^+ + AlCl_4^-$$

Which property makes this reaction possible?

A $AlCl_3$ is a covalent molecule.

B $AlCl_3$ exists as the dimer Al_2Cl_6 in the vapour.

C The aluminium atom in $AlCl_3$ has an incomplete octet of electrons.

D The chlorine atom in RCl has a vacant p orbital.

[2003 M/J (14)]

10.

Which of the following statements are correct for the sequence of compounds below considered from left to right?

NaF MgO AlN SiC

1 The electronegativity difference between the elements in each compound increases.

2 The formula-units of these compounds are isoelectronic (have the same number of electrons).

3 The bonding becomes increasingly covalent.

[2003 M/J (34)]

11.

The table gives the successive ionisation energies for an element *X*.

	1st	2nd	3rd	4th	5th	6th
ionisation energy / kJ mol^{-1}	950	1800	2700	4800	6000	12300

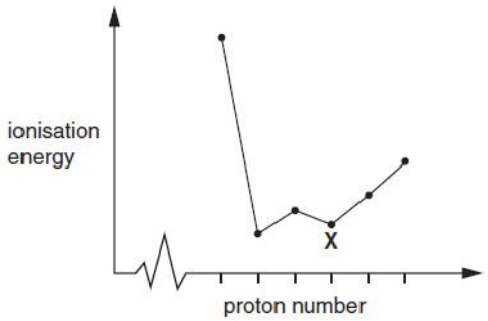
What could be the formula of the chloride of *X*?

A XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

[2003 O/N (5)]

12.

The sketch below shows the variation of first ionisation energy with proton number for six elements of consecutive proton numbers between 1 and 18 (H to Ar).



What is the identity of the element **X**?

A Mg **B** Al **C** Si **D** P

[2003 O/N (13)]

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13.
Which statements concerning the third period elements (sodium to argon) and their compounds are correct?

1 The elements become more electronegative from sodium to chlorine.

2 Aluminium oxide is the only oxide which is insoluble in water.

3 The maximum oxidation state is shown by silicon.

[2003 O/N (34)]

14.
The species Ar, K^+ and Ca^{2+} are isoelectronic (have the same number of electrons).

In what order do their radii increase?

	smallest ⟶ largest		
A	Ar	Ca^{2+}	K^+
B	Ar	K^+	Ca^{2+}
C	Ca^{2+}	K^+	Ar
D	K^+	Ar	Ca^{2+}

[2004 O/N (14)]

15.
The following species contain the same number of electrons.

In which order do their radii increase?

	smallest radius ⟶		largest radius
A	Ar	K^+	Ca^{2+}
B	Ca^{2+}	Ar	K^+
C	Ca^{2+}	K^+	Ar
D	K^+	Ar	Ca^{2+}

[2005 M/J (14)]

16.
Use of the Data Booklet is relevant to this question.

Which element is likely to have an electronegativity similar to that of aluminium?

A barium

B beryllium

C magnesium

D strontium

[2005 M/J (15)]

17.
In 1999, researchers working in the USA believed that they had made a new element and that it had the following electronic structure.

$$[Rn]\ 5f^{14}6d^{10}7s^{2}7p^{6}$$

In which Group of the Periodic Table would you expect to find this element?

A II **B** IV **C** VI **D** 0

[2005 O/N (13)]

18.
Consecutive elements *X*, *Y*, *Z* are in Period 3 of the Periodic Table. Element *Y* has the highest first ionisation energy and the lowest melting point.

What could be the identities of *X*, *Y* and *Z*?

A sodium, magnesium, aluminium

B magnesium, aluminium, silicon

C aluminium, silicon, phosphorus

D silicon, phosphorus, sulphur

[2005 O/N (14)]

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19.

Boron is a non-metallic element which is placed above aluminium in Group III of the Periodic Table. It forms a compound with nitrogen known as boron nitride which has a graphite structure.

Which of the following conclusions can be drawn from this information?

1 The empirical formula of boron nitride is BN.

2 The boron and nitride atoms are likely to be arranged alternately in a hexagonal pattern.

3 Boron nitride has a layer structure with van der Waals' forces between the layers.

[2005 O/N (33)]

20.

In which pair is the radius of the second atom greater than that of the first atom?

A Na, Mg **B** Sr, Ca **C** P, N **D** Cl, Br

[2006 M/J (13)]

21.

The oxide and chloride of an element **X** are separately mixed with water. The two resulting solutions have the same effect on litmus.

What is element **X**?

A sodium

B magnesium

C aluminium

D phosphorus

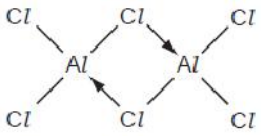
[2006 M/J (14)]

22.

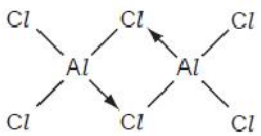
Aluminium chloride sublimes at 178 °C.

Which structure best represents the species in the vapour at this temperature?

A



B



C $Al^{\bullet} + 3Cl^{\bullet}$

D $Al^{3+}(Cl^{-})_3$

[2006 M/J (15)]

23.

The Group IV elements carbon, silicon and germanium all exist in a diamond structure. The bond lengths in these structures are given below.

element *X*	C	Si	Ge
bond length *X*–*X*/nm	0.154	0.234	0.244

Why does the bond length increase down the group?

1 Orbital overlap decreases down the group.

2 Atomic radius increases down the group.

3 Nuclear charge increases down the group.

[2006 M/J (31)]

24.

Compound **X**

- does not conduct electricity when in a liquid state,
- when added to water produces a solution that readily conducts electricity.

What could **X** be?

1 $MgCl_2$

2 $SiCl_4$

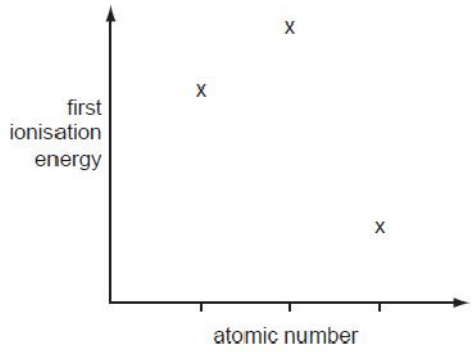
3 PCl_3

[2006 M/J (34)]

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25.

Three successive elements in the Periodic Table have first ionisation energies which have the pattern shown in the diagram.



What could be the first element of this sequence?

A C **B** N **C** F **D** Na

[2006 O/N (2)]

26.

Which statements concerning the third period elements (sodium to argon) and their compounds are correct?

1 The elements become more electronegative from sodium to chlorine.

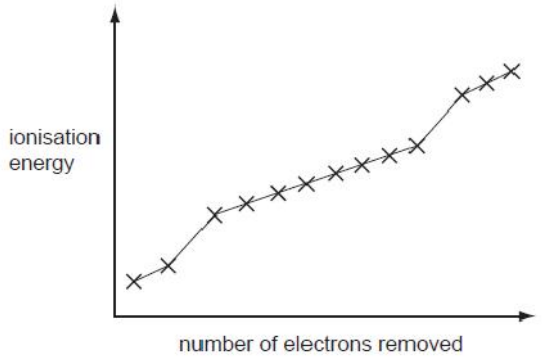
2 Aluminium oxide is the only oxide which is insoluble in water.

3 The maximum oxidation state is shown by silicon.

[2007 M/J (35)]

27.

The graph shows the first thirteen ionisation energies for element **X**.



What can be deduced about element **X** from the graph?

A It is in the second period (Li to Ne) of the Periodic Table.

B It is a d-block element.

C It is in Group II of the Periodic Table.

D It is in Group III of the Periodic Table.

[2007 O/N (4)]

28.

When dangerous chemicals are transported by road, vehicles must carry signs that indicate what measures should be taken in the event of a spillage of the chemical carried.

Which material must be used if there were a spillage of metallic sodium?

A ethanol

B jets of water

C sand

D water spray

[2007 O/N (12)]

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29.

Which species has the largest radius?

A P^{3-} **B** Cl^- **C** Ar **D** K^+

[2007 O/N (13)]

30.

Which mixtures, on heating, produce the gas ND_3?
[D = ^2_1H, an isotope of hydrogen]

1 $CaO(s)$ and $ND_4Cl(s)$

2 CH_3CN and NaOD in D_2O

3 NDH_3Cl and NaOD in D_2O

[2007 O/N (37)]

31.

In an experiment, 0.1 g samples of Na_2O, MgO, P_4O_{10} and SO_2 are added to separate 100 cm^3 volumes of water.

For which oxide is the resulting mixture most alkaline?

A Na_2O **B** MgO **C** P_4O_{10} **D** SO_2

[2008 M/J (13)]

32.

Which element is expected to show the greatest tendency to form some covalent compounds?

A aluminium

B calcium

C magnesium

D sodium

[2008 M/J (14)]

33.

Use of the Data Booklet is relevant to this question.

The combustion of fossil fuels is a major source of increasing atmospheric carbon dioxide, with a consequential rise in global warming. Another significant contribution to carbon dioxide levels comes from the thermal decomposition of limestone, in the manufacture of cement and of lime for agricultural purposes.

Cement works roast 1000 million tonnes of limestone per year and a further 200 million tonnes is roasted in kilns to make lime.

What is the total annual mass output of carbon dioxide (in million tonnes) from these two processes?

A 440 **B** 527 **C** 660 **D** 880

[2008 M/J (15)]

34.

When the yellow liquid NCl_3 is stirred into aqueous sodium hydroxide, the reaction that occurs can be represented by the following equation.

$$2NCl_3(l) + 6NaOH(aq) \rightarrow N_2(g) + 3NaCl(aq) + 3NaOCl(aq) + 3H_2O(l)$$

What will be the result of this reaction?

1 The nitrogen is oxidised.

2 A bleaching solution remains after the reaction.

3 The final solution gives a precipitate with acidified silver nitrate.

[2008 M/J (36)]

35.

Which oxide, when mixed with water, will produce the most acidic solution?

A CO **B** CO_2 **C** SiO_2 **D** P_2O_5

[2008 O/N (13)]

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36.
Aluminium chloride catalyses certain reactions by forming carbocations (carbonium ions) with chloroalkanes as shown.

$$RCl + AlCl_3 \rightarrow R^+ + AlCl_4^-$$

Which property makes this reaction possible?

A $AlCl_3$ exists as the dimer Al_2Cl_6 in the vapour.

B $AlCl_3$ is a covalent molecule.

C The aluminium atom in $AlCl_3$ has an incomplete octet of electrons.

D The chlorine atom in RCl has a vacant p orbital.

[2008 O/N (15)]

37.
The first seven ionisation energies of an element between lithium and neon in the Periodic Table are as follows.

1310 3390 5320 7450 11 000 13 300 71 000 $kJmol^{-1}$

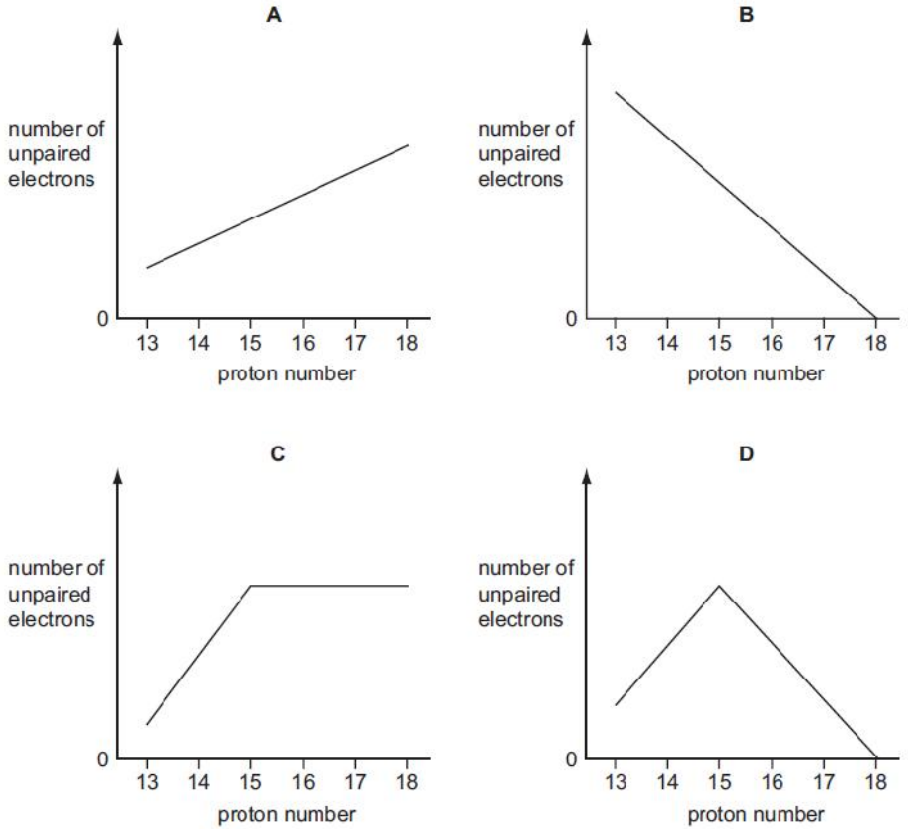
What is the outer electronic configuration of the element?

A $2s^2$ **B** $2s^22p^1$ **C** $2s^22p^4$ **D** $2s^22p^6$

[2009 M/J (3)]

38.
Use of the Data Booklet is relevant to this question.

Which graph represents the number of unpaired p orbital electrons for atoms with proton numbers 13 to 18?



[2009 M/J (4)]

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39.

Which group of particles is in order of increasing size?

A N O F

B N^{3-} O^{2-} F^{-}

C Na^{+} Mg^{2+} Al^{3+}

D Na^{+} Ne F^{-}

[2009 M/J (12)]

40.

In black and white photographic film, light converts silver chloride into metallic silver. After the film has been developed, the unreacted silver chloride is removed by reaction with sodium thiosulfate to produce a 'fixed' negative.

$$AgCl + 2Na_2S_2O_3 \rightarrow 4Na^{+} + Cl^{-} + [Ag(S_2O_3)_2]^{3-}$$

What is the function of the thiosulfate ion?

A to make the silver ions soluble

B to oxidise the silver ions

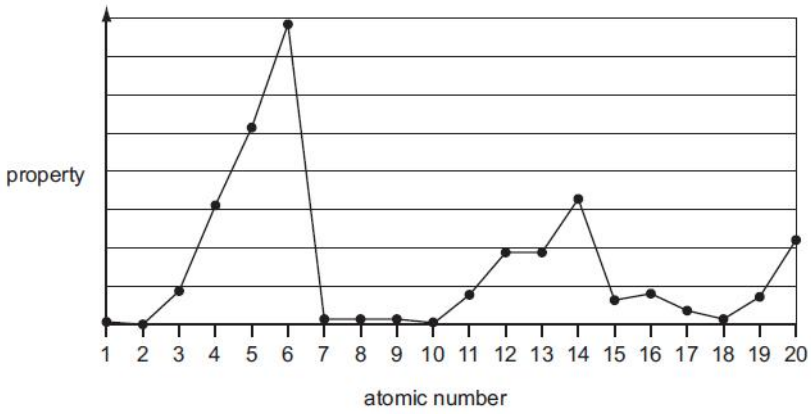
C to oxidise the silver metal

D to reduce the silver ions

[2009 M/J (15)]

41.

The following graph shows the variation of a property of the first 20 elements in the Periodic Table with the atomic number of the element.



What is the property?

A atomic radius

B first ionisation energy

C ionic radius

D melting point

[2009 O/N-11 (12)]

42.

Which statement correctly describes what happens when silicon tetrachloride is added to water?

A The $SiCl_4$ dissolves to give a neutral solution only.

B The $SiCl_4$ reacts to give an acidic solution only.

C The $SiCl_4$ reacts to give a precipitate and an acidic solution.

D The $SiCl_4$ reacts to give a precipitate and a neutral solution.

[2009 O/N-11 (13)]

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43.
The oxide and chloride of an element **X** are separately mixed with water. The two resulting solutions have the same effect on litmus.

What is element **X**?

A sodium

B magnesium

C aluminium

D phosphorus

[2009 O/N-11 (14)]

44.
Consecutive elements X, Y, Z are in the third period of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point.

What could be the identities of X, Y and Z?

A aluminium, silicon, phosphorus

B magnesium, aluminium, silicon

C silicon, phosphorus, sulfur

D sodium, magnesium, aluminium

[2010 M/J-11 (16)]

45.
Which element of the third period requires the least number of moles of oxygen for the complete combustion of 1 mol of the element?

A aluminium

B magnesium

C phosphorus

D sodium

[2010 M/J-11 (18)]

46.
Two properties of non-metallic elements and their atoms are as follows.

property 1 has an oxide that can form a strong acid in water

property 2 has **no** paired 3p electrons

Which properties do phosphorus and sulfur have?

	phosphorus	sulfur
A	1 and 2	1 only
B	1 only	1 and 2
C	1 and 2	1 and 2
D	2 only	1 only

[2010 M/J-11 (19)]

47.
When gaseous chemicals are transported by road or by rail they are classified as follows.

flammable non-flammable poisonous

Which commonly transported gas is non-flammable?

A butane

B hydrogen

C oxygen

D propene

[2010 M/J-11 (20)]

48.
Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?

A A phosphorus atom has one more proton in its nucleus.

B The atomic radius of a phosphorus atom is greater.

C The outer electron in a phosphorus atom is more shielded.

D The outer electron in a phosphorus atom is paired.

[2010 O/N-11 (13)]

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49.

Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?

A The nuclear charge of the elements increases.

B The outer electron is in an 's' subshell.

C The repulsion between spin-paired electrons increases.

D The shielding effect of the inner shells increases.

[2011 M/J-11 (5)]

50.

Which oxides react with water to give a solution of pH 10 or higher?

1 CaO

2 Na_2O

3 SrO

[2011 M/J-11 (35)]

51.

Use of the Data Booklet is relevant to this question.

Which element is likely to have an electronegativity similar to that of aluminium?

A barium

B beryllium

C magnesium

D strontium

[2011 M/J-12 (12)]

52.

In 1999, researchers working in the USA believed that they had made a new element and that it had the following electronic configuration.

$$[Rn]\ 5f^{14}6d^{10}7s^{2}7p^{6}$$

In which Group of the Periodic Table would you expect to find this element?

A II **B** IV **C** VI **D** 0

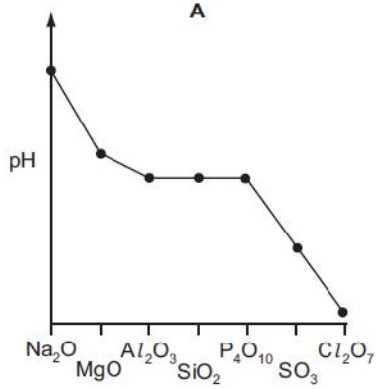
[2011 M/J-12 (13)]

53.

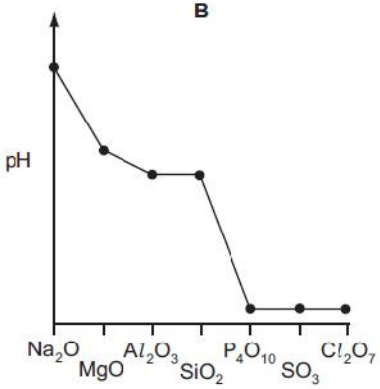
The highest oxides of the elements sodium to chlorine are separately added to water.

Which diagram best represents the pH of the resulting mixtures?

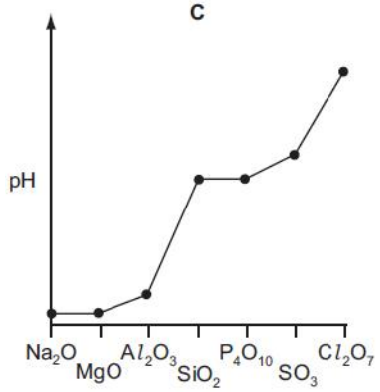
A



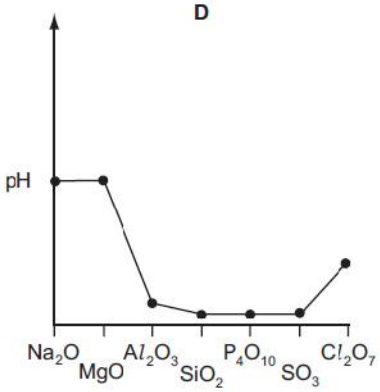
B



C



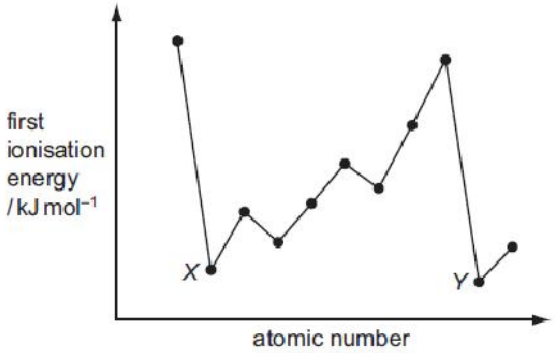
D



[2011 M/J-12 (14)]

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54.
The diagram shows the first ionisation energies of 11 consecutive elements.



Which type of elements are labelled *X* and Y?

A Group I metals

B Group II metals

C halogens

D noble gases

[2011 M/J-12 (15)]

55.
Why does aluminium oxide dissolve in sodium hydroxide solution?

A Aluminium oxide can behave as a base.

B Aluminium oxide can behave as an acid.

C Aluminium oxide has a giant structure.

D The bonding in aluminium oxide is ionic.

[2011 M/J-12 (16)]

56.
When the yellow liquid NCl_3 is stirred into aqueous sodium hydroxide, the reaction that occurs can be represented by the following equation.

$$2NCl_3(l) + 6NaOH(aq) \rightarrow N_2(g) + 3NaCl(aq) + 3NaOCl(aq) + 3H_2O(l)$$

What will be the result of this reaction?

1 The nitrogen undergoes a redox reaction.

2 A bleaching solution remains after the reaction.

3 The final solution gives a precipitate with acidified silver nitrate.

[2011 M/J-12 (35)]

57.
Which element shows the greatest tendency to form some covalent compounds?

A aluminium

B magnesium

C neon

D potassium

[2011 O/N-11 (13)]

58.
Ar, Ca^{2+} and K^+, contain the same number of electrons.

In which order do their radii increase?

	smallest radius →		largest radius
A	Ar	K^+	Ca^{2+}
B	Ca^{2+}	Ar	K^+
C	Ca^{2+}	K^+	Ar
D	K^+	Ar	Ca^{2+}

[2011 O/N-12 (19)]

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59.

Nitrogen and phosphorus are both in Group V of the Periodic Table. Phosphorus forms a chloride with the formula PCl_5.

Why is it **not** possible for nitrogen to form NCl_5?

1 Nitrogen's outer shell can only contain eight electrons.

2 Nitrogen cannot have oxidation state +5.

3 Nitrogen is almost inert.

[2012 M/J-11 (33)]

60.

The period 4 elements gallium (Ga), germanium (Ge), arsenic (As) and selenium (Se) are the elements below aluminium, silicon, phosphorus and sulfur in the Periodic Table, a portion of which is shown below.

period 3 elements	Al	Si	P	S
period 4 elements	Ga	Ge	As	Se

The properties of each period 4 element resemble those of the period 3 element directly above it.

Which period 4 elements form oxides that dissolve in water to give an acid solution?

A As and Se **B** Ga and Ge **C** Ga and Se **D** Se only

[2012 M/J-12 (15)]

61.

Why is the ionic radius of a chloride ion larger than the ionic radius of a sodium ion?

A A chloride ion has one more occupied electron shell than a sodium ion.

B Chlorine has a higher proton number than sodium.

C Ionic radius increases regularly across the third period.

D Sodium is a metal, chlorine is a non-metal.

[2012 O/N-11 (13)]

62.

Use of the Data Booklet is relevant to this question.

1.15 g of a metallic element reacts with 300 cm^3 of oxygen at 298 K and 1 atm pressure, to form an oxide which contains O^{2-} ions.

What could be the identity of the metal?

A calcium

B magnesium

C potassium

D sodium

[2012 O/N-11 (17)]

63.

Elements **X** and **Y** are both in period three.

When the chloride of **X** is added to water, it reacts and a solution of pH 2 is produced.

When the chloride of **Y** is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

A Both chlorides hydrolyse in water.

B **X** is phosphorus and **Y** is aluminium.

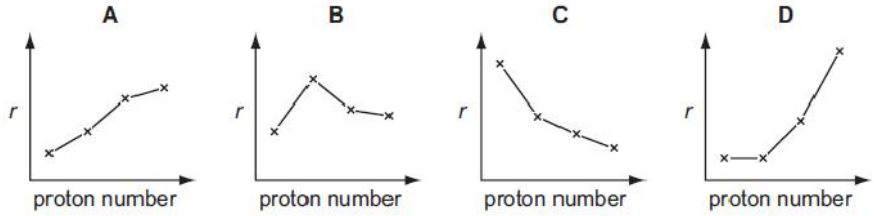
C **X** is silicon and **Y** is sodium.

D **X** is sodium and **Y** is phosphorus.

[2012 O/N-11 (18)]

64.

Which diagram shows the variation of the metallic radius *r* of the Group I elements, Li, Na, K and Rb, with increasing proton (atomic) number?



[2012 O/N-11 (19)]

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65.

Use of the Data Booklet is relevant to this question.

Why is the ionic radius of a sulfide ion larger than the ionic radius of a potassium ion?

A Ionic radius always decreases with increasing atomic number.

B Positive ions have smaller radii than negative ions.

C The potassium ion has more protons in its nucleus than the sulfide ion.

D The sulfide ion is doubly charged; the potassium ion is singly charged.

[2012 O/N-13 (12)]

66.

Which oxide, when mixed with water, will produce the solution with the lowest pH?

A CO_2 **B** Na_2O **C** P_4O_{10} **D** SiO_2

[2012 O/N-13 (18)]

67.

An element X and compound YZ react separately with acid as shown.

$$X(s) + 2H^+(aq) \rightarrow X^{2+}(aq) + H_2(g)$$

$$YZ(s) + 2H^+(aq) \rightarrow Y^{2+}(aq) + H_2Z(g)$$

When 1.0 g of either X or YZ is reacted with an excess of acid, the total volume of gas formed is the same.

Which statements are correct?

1 $A_r(X) = M_r(YZ)$

2 X and Y are metals.

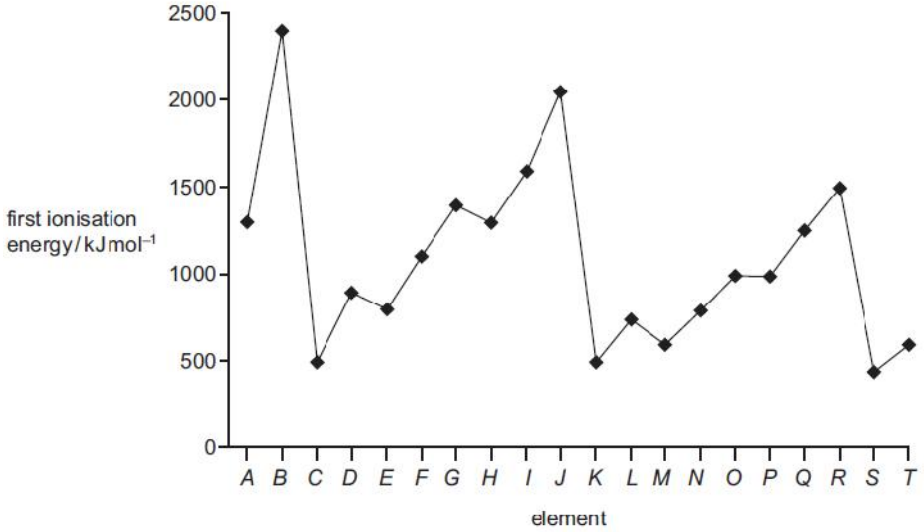
3 X and Y must both be in the same Group of the Periodic Table.

[2012 O/N-13 (34)]

68.

The first ionisation energies of twenty successive elements in the Periodic Table are represented in the graph.

The letters given are not the normal symbols for these elements.



Which statements about this graph are correct?

1 Elements *B*, *J* and *R* are in Group 0 of the Periodic Table.

2 Atoms of elements *D* and *L* contain two electrons in their outer shells.

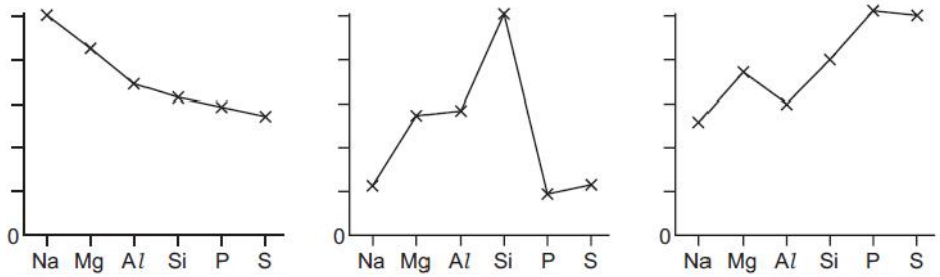
3 Atoms of elements *G* and *O* contain a half-filled p subshell.

[2013 M/J-11 (34)]

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69.

The trends in three physical properties of the elements Na, Mg, Al, Si, P and S are shown in the graphs.



Which physical property is **not** illustrated?

A atomic radius

B electrical conductivity

C first ionisation energy

D melting point

[2013 M/J-12 (16)]

70.

Consecutive elements **X**, **Y** and **Z** are in the third period of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.

What could be the identities of **X**, **Y** and **Z**?

A sodium, magnesium, aluminium

B magnesium, aluminium, silicon

C aluminium, silicon, phosphorus

D silicon, phosphorus, sulfur

[2013 O/N-11 (19)]

71.

Use of the Data Booklet is relevant to this question.

Carbon and nitrogen are adjacent in the Periodic Table.

Which properties do they both have?

1 There is an empty 2p orbital in one atom of the element.

2 The principal quantum number of the highest occupied orbital is 2.

3 They form compounds in which their atoms form bonds with four other atoms.

[2013 O/N-11 (32)]

72.

Use of the Data Booklet is relevant to this question.

Element X forms X^- ions that can be oxidised to element X by acidified potassium manganate(VII).

What could be the values of the first four ionisation energies of X?

	1st	2nd	3rd	4th
A	418	3070	4600	5860
B	577	1820	2740	11 600
C	590	1150	4940	6480
D	1010	1840	2040	4030

[2013 O/N-13 (4)]

73.

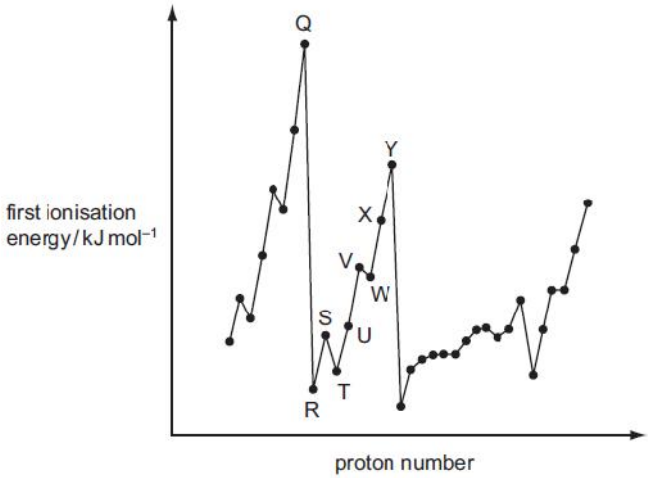
Which oxide is insoluble in aqueous sodium hydroxide?

A MgO **B** Al_2O_3 **C** P_4O_{10} **D** SO_2

[2013 O/N-13 (17)]

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74.
The graph below shows the variation of the first ionisation energy with the number of protons for some elements.



Which statement is correct?

A Elements Q and Y are in the same period in the Periodic Table.

B The general increase from elements R to Y is due to increasing atomic radius.

C The small decrease between elements S and T is due to decreased shielding.

D The small decrease between elements V and W is due to repulsion between paired electrons.

[2013 O/N-13 (18)]

75.
Use of the Data Booklet is relevant to this question.

Elements **J** and **K** react together to form compound **L**. Elements **J** and **K** are both in Period 3. Element **J** has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element **K**.

Which compound could be **L**?

A $MgCl_2$ **B** MgS **C** Na_2S **D** PCl_3

[2013 O/N-13 (19)]

76.
Which chlorides of Period 3 elements will form a neutral solution when added to water?

1 $NaCl$

2 Al_2Cl_6

3 PCl_5

[2013 O/N-13 (36)]

77.
What is the order of increasing melting point of the four chlorides shown?

CCl_4 HCl $MgCl_2$ PCl_5

	lowest melting point → highest melting point			
A	CCl_4	HCl	PCl_5	$MgCl_2$
B	HCl	CCl_4	PCl_5	$MgCl_2$
C	HCl	PCl_5	CCl_4	$MgCl_2$
D	$MgCl_2$	PCl_5	CCl_4	HCl

[2014 M/J-11 (14)]

78.
Which description of the bonding and acid/base nature of aluminium oxide is correct?

	bonding	acid / base nature
A	covalent	amphoteric
B	covalent	basic
C	ionic	amphoteric
D	ionic	basic

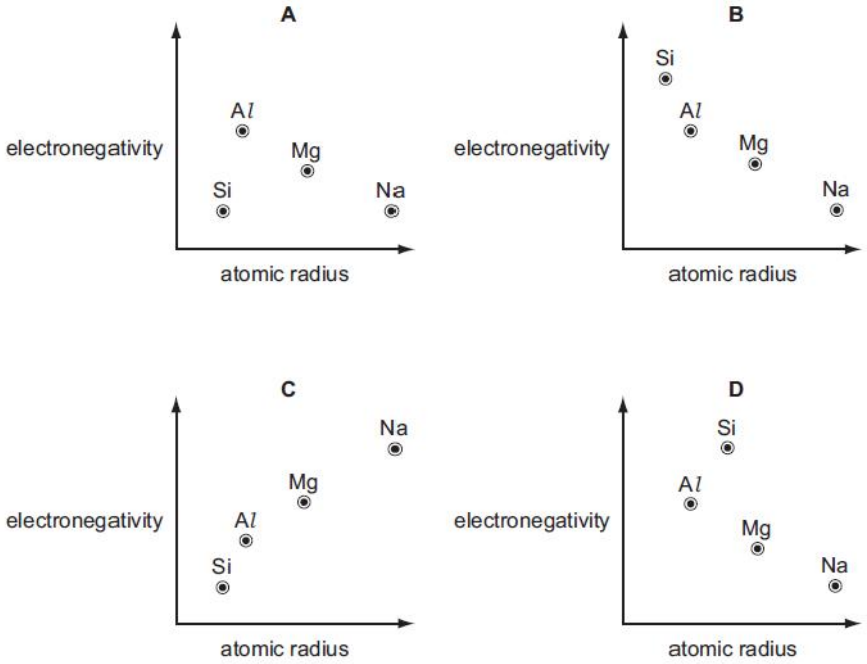
[2014 M/J-11 (16)]

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79.

Use of the Data Booklet is relevant to this question.

Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?



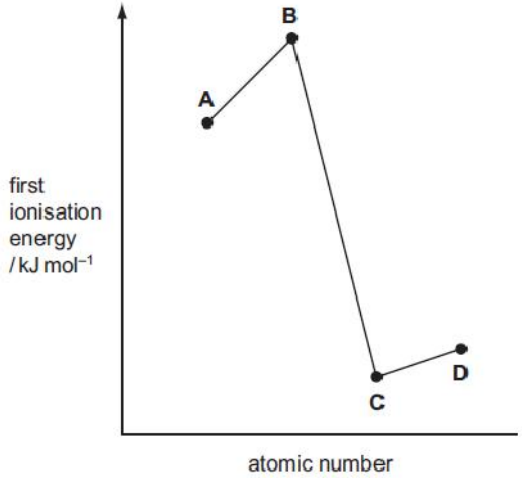
[2014 M/J-11 (19)]

80.

Shown on the graph are the relative values of the first ionisation energies of four elements that have consecutive atomic numbers.

One of the elements reacts with hydrogen to form a covalent compound with formula HX.

Which element could be X?



[2014 M/J-12 (10)]

81.

X and Y are oxides of different Period 3 elements.

If one mole of Y is added to water, the solution formed is neutralised by exactly one mole of X.

What could be the identities of X and Y?

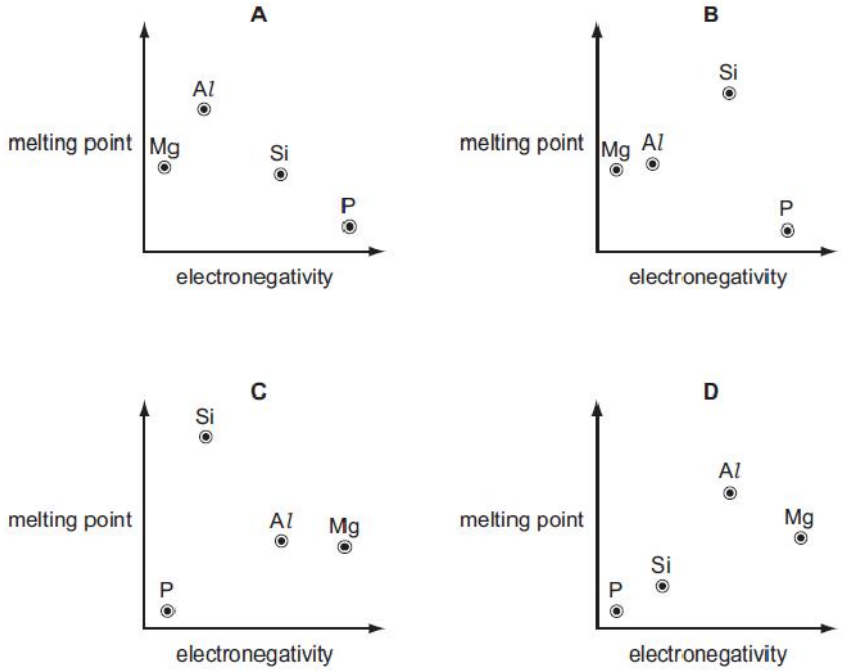
	X	Y
A	Al_2O_3	P_4O_{10}
B	Al_2O_3	SO_3
C	Na_2O	P_4O_{10}
D	Na_2O	SO_3

[2014 M/J-12 (13)]

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82.

Which graph correctly shows the relative melting points of the elements Mg, Al, Si and P plotted against their relative electronegativities?



[2014 M/J-12 (16)]

83.

A student investigated the chloride of a Period 3 element. This is what he wrote down as his record of what he did and what he saw.

> The compound was a white crystalline solid. It dissolved easily in water to give a solution of pH 12. When placed in a test-tube and heated in a roaring Bunsen flame, the compound melted after several minutes heating.

What can be deduced from this record?

A At least one of the recorded observations is incorrect.

B The compound was magnesium chloride, $MgCl_2$.

C The compound was phosphorus pentachloride, PCl_5.

D The compound was sodium chloride, $NaCl$.

[2014 M/J-13 (12)]

84.

The species Ne, Na^+ and Mg^{2+} are isoelectronic. This means that they have the same number of electrons.

In which order do their radii increase?

	smallest ⟶		largest
A	Ne	Na^+	Mg^{2+}
B	Ne	Mg^{2+}	Na^+
C	Mg^{2+}	Ne	Na^+
D	Mg^{2+}	Na^+	Ne

[2014 M/J-13 (16)]

85.

Which properties do compounds of aluminium and silicon have in common?

A Aqueous solutions of their chlorides contain aluminium or silicon cations.

B Their chlorides have co-ordinate bonding.

C Their oxides are amphoteric.

D Their oxides are insoluble in water.

[2014 M/J-13 (18)]

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86.

Element **X**, in Period 3, has the following properties.

- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise HCl(aq).

What is element **X**?

A Mg **B** Al **C** Si **D** P

[2014 O/N-11 (12)]

87.

Which property is **not** associated with the element sodium?

A It can react with cold water to form hydrogen.

B It forms a basic oxide.

C It forms a neutral chloride.

D It is an oxidising agent.

[2014 O/N-11 (13)]

88.

Use of the Data Booklet is relevant to this question.

A sample of potassium oxide, K_2O, is dissolved in 250 cm^3 of distilled water. 25.0 cm^3 of this solution is titrated against sulfuric acid of concentration 2.00 mol dm^{-3}. 15.0 cm^3 of this sulfuric acid is needed for complete neutralisation.

Which mass of potassium oxide was originally dissolved in 250 cm^3 of distilled water?

A 2.83 g **B** 28.3 g **C** 47.1 g **D** 56.6 g

[2014 O/N-11 (15)]

89.

Which oxide does **not** react with cold dilute sodium hydroxide to produce a salt?

A Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2

[2014 O/N-11 (19)]

90.

Use of the Data Booklet is relevant to this question.

In some types of spectroscopy, it is important to know if ions are isoelectronic. This means that they contain equal numbers of electrons.

Which ion is **not** isoelectronic with K^+?

A Ca^{2+} **B** Cl^- **C** S^{2-} **D** Ti^{3+}

[2014 O/N-13 (2)]

91.

X, **Y** and **Z** are compounds of three elements in Period 3. Their electrical conductivities are shown in the table.

	X	Y	Z
conductivity of the compound in the molten state	good	does not conduct	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good	does not conduct

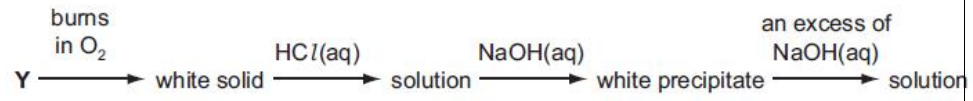
What could be compounds **X**, **Y** and **Z**?

	X	Y	Z
A	Al_2O_3	$SiCl_4$	NaF
B	NaF	Al_2O_3	$SiCl_4$
C	NaF	$SiCl_4$	SiO_2
D	$SiCl_4$	Al_2O_3	SiO_2

[2014 O/N-13 (14)]

92.

An element **Y** reacts according to the following sequence.



What could be element **Y**?

A Al **B** Ca **C** Mg **D** P

[2014 O/N-13 (17)]

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93.
One molecule of the oxide of element **Z** reacts with six molecules of water to produce an acidic compound.

What is element **Z**?

A aluminium

B phosphorus

C sodium

D sulfur

[2014 O/N-13 (18)]

94.
A student examines two semi-precious stones; one is agate, SiO_2, and the other is calcite, $CaCO_3$.

How could they be distinguished?

A Add a fixed amount of cold aqueous sodium hydroxide to each separately and measure any temperature change.

B Heat each separately over a gentle Bunsen flame and note which one melts first.

C Shake each separately with dilute hydrochloric acid and test any gas formed.

D Shake each separately with distilled water and add a few drops of Universal Indicator.

[2014 O/N-13 (19)]

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Chemical Periodicity – 2021 AS

1. Nov/2021/Paper_22/No.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.

.....

.....

.....

.....

..... [2]

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

.....

.....

.....

.....

..... [2]

(iv) Complete the row in the table labelled 'maximum oxidation number'. [1]

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

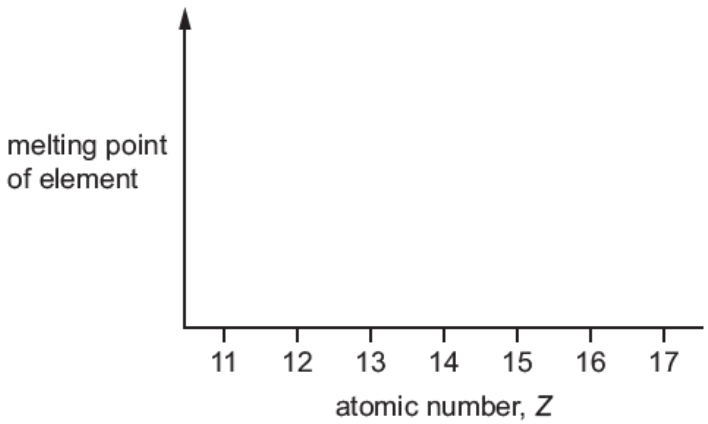
.....

.....

.....

..... [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, $_{31}Ga$, 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
$_{5}B$	2.34	3930	0.020
$_{13}Al$		2470	0.050
$_{31}Ga$	5.91	2400	
$_{49}In$	7.30		0.081
$_{81}Tl$	11.8	1460	0.095

Complete the table by predicting values for the missing data. [3]

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(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 $In_2Br_6(g)$.

[2]

[Total: 17]

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2. Nov/2021/Paper_23/No.3

Phosphorus is a reactive Period 3 element.

(a) Phosphorus has several allotropes. Details of two allotropes are given.

allotrope of phosphorus	formula	melting point / °C
white	P_4	44
red	P	590

(i) White phosphorus and red phosphorus both have covalent bonding.

Suggest the types of structure shown by white phosphorus (P_4) and red phosphorus (P).

Explain why red phosphorus (P) has a higher melting point than white phosphorus (P_4).

structure of P_4 .....

structure of P .....

explanation .....

.....

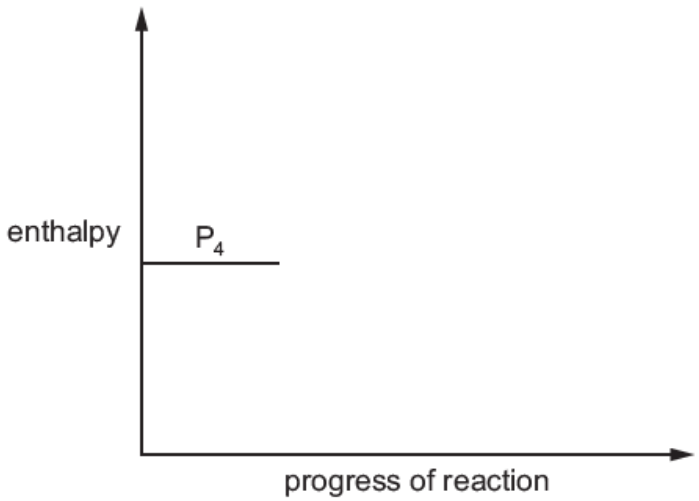
.....

[3]

(ii) Red phosphorus (P) forms when white phosphorus (P_4) is exposed to sunlight.

$$\underset{\text{white}}{\tfrac{1}{4}P_4(s)} \rightarrow \underset{\text{red}}{P(s)} \qquad \Delta H = -17.6\,\text{kJ mol}^{-1}$$

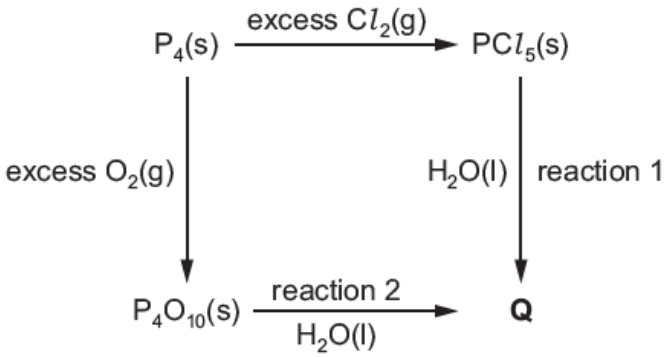
Use this information to draw a reaction pathway diagram to show the formation of red phosphorus (P) from white phosphorus (P_4).



[1]

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(b) Some reactions of $P_4(s)$ are shown in the reaction scheme.



(i) State the oxidation number of phosphorus in P_4O_{10}.

..... [1]

(ii) Deduce the identity of **Q** and hence construct chemical equations for reactions 1 and 2.

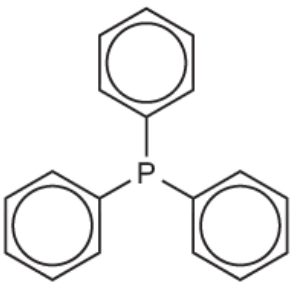
reaction 1 PCl_5 + ...H_2O → .....

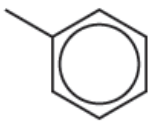
reaction 2 P_4O_{10} + ...H_2O → .....

[2]

(c) Triphenylphosphine is used in a type of reaction known as a *Wittig reaction*.

triphenylphosphine



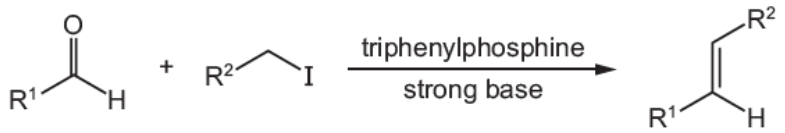
where  = $-C_6H_5$

(i) Give the empirical formula of triphenylphosphine.

..... [1]

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In a Wittig reaction, an aldehyde reacts with a halogenoalkane to form an alkene. The conversion is shown in the following unbalanced equation.



Compound **H** can be made from propanal, C_2H_5CHO. Stage 3 in the reaction scheme is a Wittig reaction.

stage 1 $C_2H_5CHO \xrightarrow{NaBH_4}$ **G**

stage 2 **G** $\xrightarrow{\text{red phosphorus and } I_2}$ $C_2H_5CH_2I$

stage 3 (Wittig reaction) $C_2H_5CH_2I + C_2H_5CHO \xrightarrow[\text{strong base}]{\text{triphenylphosphine}}$ **H**

(ii) State the types of reaction that occur in stages 1 and 2.

stage 1 .....

stage 2 .....

[2]

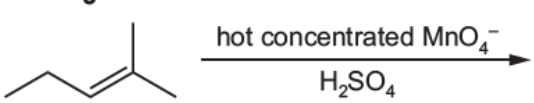
(iii) Draw the structures of **G** and **H** in the boxes provided.

G	**H**

[2]

(d) Identify the organic products formed when compound **J**, shown below, is heated with hot concentrated acidified manganate(VII) ions.

J



[2]

[Total: 14]

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3. June/2021/Paper_11/No.12

Element X is in Period 3. Element X forms a solid oxide Y.

Y reacts with hot concentrated hydrochloric acid. Y reacts with hot aqueous sodium hydroxide to form a compound in which X is part of an anion.

How many p electrons does one atom of X have in its outer shell?

A 0 **B** 1 **C** 2 **D** 3

4. June/2021/Paper_11/No.13

The gaseous products of heating a mixture of $Ca(OH)_2$ and NH_4Cl are passed through solid CaO. A single gaseous product, W, is collected.

A sample of W reacts with $Cl_2(g)$ to produce two gases, X and Y.

X is an element. Y is acidic.

Y reacts with W to produce Z.

What are X and Z?

	X	Z
A	N_2	$CaCl_2$
B	N_2	NH_4Cl
C	O_2	$CaCl_2$
D	O_2	NH_4Cl

5. June/2021/Paper_11/No.35

Which statements are correct going across Period 3 from sodium to chlorine?

1 The charge on the nucleus increases, pulling the electrons closer to it.

2 The radius of the most common ion of each element decreases.

3 The shielding caused by inner electrons decreases, so the outer electrons are pulled closer to the nucleus.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

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6. June/2021/Paper_12/No.13

L and M are elements in Period 3 of the Periodic Table.

- The oxide of L is a solid at room temperature. This oxide has a giant structure.
- The chloride of L does not react with water.
- Argon is the only element in Period 3 with a lower melting point than M.

Which formula represents a compound of elements L and M?

A Al_2S_3 **B** MgS **C** $NaCl$ **D** PCl_5

7. June/2021/Paper_13/No.19

Two oxides of Period 3 elements are added separately to water. Both react to form colourless solutions. One solution is alkaline, the other is acidic.

What could be the two oxides?

A Al_2O_3 and SiO_2

B Al_2O_3 and P_4O_{10}

C Na_2O and P_4O_{10}

D Na_2O and SiO_2

8. June/2021/Paper_13/No.36

Which statements help to explain the increase in melting point from sodium to aluminium?

1 The charge on the metal ion increases.

2 There are more delocalised electrons per metal ion.

3 The radius of the metal ion decreases.

9. June/2021/Paper_23/No.3

Separate samples of **R**, **S**, **T** and **U** are added to cold water. The identity of each sample is unknown. However, each sample is known to be pure and can only be one of $Ba(OH)_2$, $NaCl$, P_4O_{10} or $SiCl_4$.

(a) (i) Use the observations in the table to identify each sample as one of $Ba(OH)_2$, $NaCl$, P_4O_{10} and $SiCl_4$. Write your answers in the table.

	state at room temperature	observations on addition of sample to water	identity of sample
R	solid	alkaline, colourless solution is produced, some white solid remains	
S	solid	white solid disappears, solution is neutral	
T	liquid	misty fumes produced, white solid is made in vigorous reaction	
U	solid	acidic, colourless solution produced in vigorous reaction	

[4]

(ii) Identify the formula of the white solid made when sample **T** reacts with water.

..... [1]

(iii) Name the solution formed when sample **U** reacts with water.

..... [1]

(b) Magnesium oxide and aluminium oxide have properties typical of ceramic materials.

(i) Name **one** physical property typical of ceramic materials.

..... [1]

(ii) Give the formula of another Period 3 oxide which behaves as a ceramic material.

..... [1]

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(c) Tungsten oxide, W_xO_y, is used to give colour to ceramic materials.

A sample of W_xO_y contains 79.29% tungsten by mass.

Calculate the empirical formula of W_xO_y.

Show your working.

empirical formula = ...

[3]

[Total: 11]

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Periodic Table: Chemical Periodicity – 2022 June AS Chemistry 9701

1. June/2022/Paper_11/No.18

Which statement for the element in Period 3 and Group 13 of the Periodic Table is correct?

A It has the highest melting point of the elements in its period.

B It has exactly one electron in its shell with principal quantum number 3.

C It forms an oxide that reacts with aqueous sodium hydroxide.

D It forms a chloride that dissolves in water to give a neutral solution.

2. June/2022/Paper_11/No.19

A student reacts 0.100 mol of each of sodium, magnesium and phosphorus atoms separately with an excess of oxygen.

Which rows are correct?

	oxide	mass of oxide formed / g
1	sodium	3.10
2	magnesium	4.03
3	phosphorus	7.10

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

3. June/2022/Paper_12/No.17

$NH_3(aq)$ is added to separate samples of $NaCl(aq)$, $MgCl_2(aq)$, $BaCl_2(aq)$ and $SiCl_4(l)$. Under the conditions of this experiment, only two samples will produce a white precipitate when $NH_3(aq)$ is added.

What are these two samples?

A $MgCl_2(aq)$ and $BaCl_2(aq)$

B $MgCl_2(aq)$ and $SiCl_4(l)$

C $NaCl(aq)$ and $BaCl_2(aq)$

D $NaCl(aq)$ and $SiCl_4(l)$

4. June/2022/Paper_12/No.18

Why is the ionic radius of a sulfide ion larger than the ionic radius of a potassium ion?

A Ionic radius always decreases with increasing atomic number.

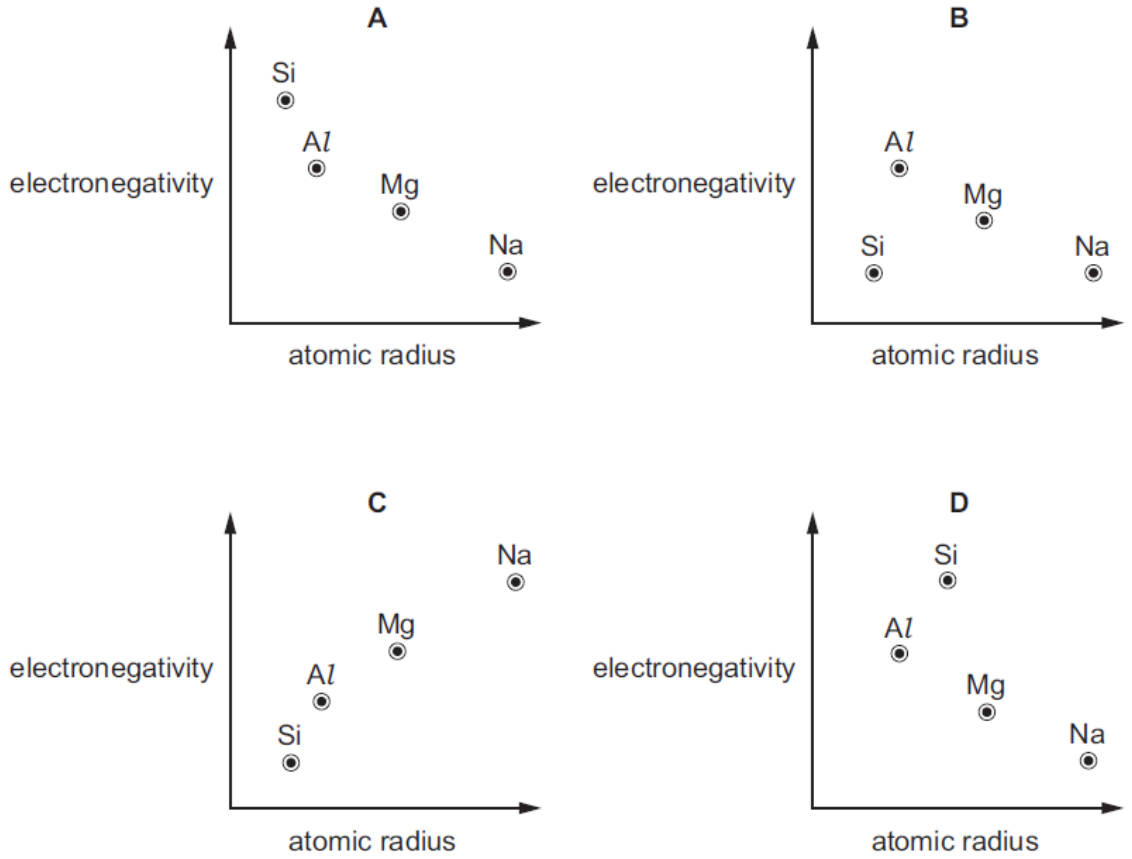
B Positive ions always have smaller radii than negative ions.

C The potassium ion has more protons in its nucleus than the sulfide ion.

D The sulfide ion is doubly charged; the potassium ion is singly charged.

5. June/2022/Paper_12/No.19

Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?



6. June/2022/Paper_13/No.17

Which ion has the smallest radius?

A Al^{3+} **B** Ba^{2+} **C** Mg^{2+} **D** Na^{+}

7. June/2022/Paper_13/No.18

Which row is correct?

	element with the greater fifth ionisation energy	element with an amphoteric oxide
A	aluminium	aluminium only
B	aluminium	both aluminium and phosphorus
C	phosphorus	aluminium only
D	phosphorus	both aluminium and phosphorus

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8. June/2022/Paper_13/No.19

Each of the chlorides listed is added to water.

1 aluminium chloride

2 magnesium chloride

3 silicon tetrachloride

4 phosphorus pentachloride

Which chlorides form an aqueous solution that reacts with sodium carbonate to produce carbon dioxide?

A 1 and 2 only

B 3 and 4 only

C 1, 3 and 4 only

D 1, 2, 3 and 4

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9. June/2022/Paper_23/No.1(c, d)

(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]

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10. June/2022/Paper_23/No.2(a)

(a) Period 3 elements and their compounds show trends in their physical properties.

(i) On Fig. 2.1 sketch a graph to show the melting points of the first five elements in Period 3.

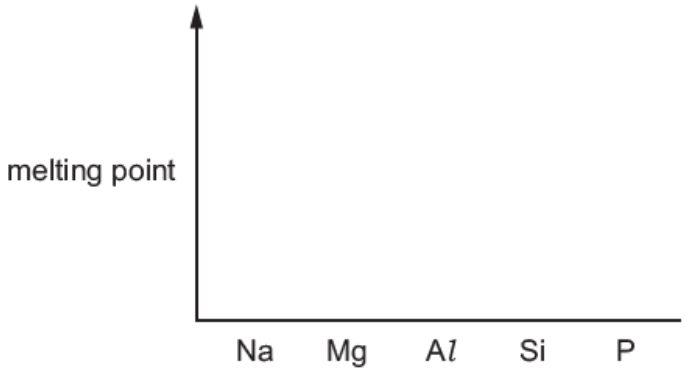


Fig. 2.1

[3]

(ii) Complete Table 2.1 with information for sodium chloride and phosphorus(V) chloride.

Table 2.1

	sodium chloride	phosphorus(V) chloride
state at room temperature		
name of change which occurs on addition of water		
pH of final solution		

[3]

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Periodic Table: Chemical Periodicity – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.17

The electrical conductivities of two compounds, Y and Z, are shown.

	for Y	for Z
conductivity of the compound in the liquid state	good	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good

What are compounds Y and Z?

	Y	Z
A	Al_2O_3	$SiCl_4$
B	$NaCl$	Al_2O_3
C	$NaCl$	$SiCl_4$
D	$SiCl_4$	Al_2O_3

2. Nov/2022/Paper_11/No.18

Which row describes the relative sizes of the ionic radii of Na^+, Mg^{2+} and S^{2-}?

	smallest ⟶		largest
A	Na^+	Mg^{2+}	S^{2-}
B	Mg^{2+}	Na^+	S^{2-}
C	S^{2-}	Na^+	Mg^{2+}
D	S^{2-}	Mg^{2+}	Na^+

3. Nov/2022/Paper_11/No.19

The oxides BaO, CaO, MgO and SrO all produce alkaline solutions when added to water.

Which oxide produces the saturated solution with the highest pH?

A BaO **B** CaO **C** MgO **D** SrO

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4. Nov/2022/Paper_11/No.25

Separate 1.0 g samples of Na_2O, MgO, Al_2O_3, SiO_2, NaCl, $MgCl_2$, Al_2Cl_6 and $SiCl_4$ are added to separate beakers containing water and stirred.

The number of beakers containing a white solid is Q.

An excess of NaOH(aq) is then added to each beaker and stirred.

The number of beakers now containing a white solid is R.

Which row is correct?

	Q	R
A	3	2
B	3	3
C	4	3
D	4	4

5. Nov/2022/Paper_12/No.17

Element X requires strong heating to react with oxygen.

Element X reacts with chlorine to give a covalently-bonded chloride.

What could be the identity of element X?

A magnesium

B phosphorus

C sodium

D silicon

6. Nov/2022/Paper_12/No.18

The melting points of the Period 3 elements sodium to aluminium are shown in the table.

element	Na	Mg	Al
melting point / K	371	923	932

Which factor explains the **increase** in melting points from sodium to aluminium?

A the change in first ionisation energy from sodium to aluminium

B the increase in electronegativity from sodium to aluminium

C the increase in the A_r of the elements from sodium to aluminium

D the increase in the number of outer electrons in each atom from sodium to aluminium

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7. Nov/2022/Paper_12/No.25

T is an element in Period 3.

The first ionisation energy of T is lower than that of the element with one less proton.

The oxide of T does not react with water.

What is the identity of T?

A aluminium

B silicon

C sodium

D sulfur

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8. Nov/2022/Paper_21/No.3(a, b)

Some of the common chlorides of Period 3 elements are shown in the list.

$$NaCl \quad MgCl_2 \quad AlCl_3 \quad SiCl_4 \quad PCl_5$$

(a) From this list, identify:

(i) all the chlorides that have giant ionic structures in the solid state

..... [1]

(ii) all the chlorides that react vigorously with water to form strongly acidic solutions

..... [1]

(iii) the chloride that dissolves in water to form a neutral solution

..... [1]

(iv) the chloride formed from the **element** with the highest melting point.

..... [1]

(b) $NaCl$ is one product of the reaction of chlorine gas and cold aqueous sodium hydroxide.

Identify the other products.

..... [1]

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9. Nov/2022/Paper_22/No.2(a, b)

The chlorides of some of the Period 3 elements are shown in Table 2.1.

Table 2.1

Period 3 chloride	NaCl	$AlCl_3$	$SiCl_4$	PCl_5	PCl_3	SCl_2
bonding					C	C
structure					S	S
oxidation state of Period 3 element						

(a) Complete Table 2.1.

- Identify the bonding shown by each chloride under standard conditions.
  Use C = covalent, I = ionic, M = metallic.
- Identify the structure shown by each chloride under standard conditions.
  Use G = giant, S = simple.
- Deduce the oxidation state of the Period 3 element in each chloride.

[4]

(b) Write equations for the reactions of NaCl and PCl_5 with water.
Include state symbols in both equations.

NaCl .....

PCl_5 .....

[3]

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Periodic Table: Chemical Periodicity – 2023 AS Chemistry 9701

1. Nov/2023/Paper_ 9701/11/No.16

X, Y and Z are elements all found within Groups 13, 14 and 15 of the Periodic Table.

X is in the same group in the Periodic Table as Y.

Y and Z are in Period 3.

The first ionisation energy of X is greater than the first ionisation energy of Y.

The melting point of Z is less than the melting point of Y.

Y and Z both form chlorides which are white solids. These white solids react with water to produce solutions with a pH of less than 4.

Which row of the table shows the possible identities of X and Y?

	X	Y
A	B	*Al*
B	Ge	Si
C	As	P
D	N	P

2. Nov/2023/Paper_ 9701/11/No.17

Which row about silicon, Si, and magnesium, Mg, and their ions is correct?

	comparison of silicon and magnesium	explanation
A	Si has a greater atomic radius than Mg.	Si has electrons in 3p orbitals. Mg has electrons in the 3s orbital only.
B	Si has a lower electrical conductivity than Mg.	Si has 4 delocalised electrons per atom. Mg only has 2 delocalised electrons per atom.
C	Si has a lower melting point than Mg.	Si has covalent bonding. Mg has metallic bonding.
D	The radius of Si^{4+} is smaller than the radius of Mg^{2+}.	Si has a greater nuclear charge than Mg.

3. Nov/2023/Paper_ 9701/11/No.18

Bromocresol green is an acid-base indicator. Below a pH of 3.8 it is yellow. Above a pH of 5.4 it is blue. Between these values it is green.

Bromocresol green is added to the aqueous solution formed when the chloride of element T is added to water. The colour becomes yellow.

When an excess of the solid oxide of element U is slowly added to this yellow solution, the indicator turns green then blue.

Which row could identify element T and element U?

	element T	element U
A	silicon	sodium
B	silicon	phosphorus
C	magnesium	sodium
D	magnesium	phosphorus

4. Nov/2023/Paper_ 9701/12/No.18

Which row gives the best description of the variations in the melting points and the first ionisation energies of the elements in Period 3 from sodium to argon?

	melting points	first ionisation energies
A	increase up to a peak at aluminium then decrease	generally decrease
B	increase up to a peak at aluminium then decrease	generally increase
C	increase up to a peak at silicon then decrease	generally decrease
D	increase up to a peak at silicon then decrease	generally increase

5. Nov/2023/Paper_ 9701/12/No.19

X and Y are atoms of different elements in Period 3 of the Periodic Table. Neither X nor Y is argon.

X is a non-metal.

X has a greater atomic radius than Y.

Which statement is correct?

A X has more occupied electron shells than Y.

B X has more protons in each atom than Y.

C X has the same number of outer electrons in each atom as Y.

D Y is a non-metal.

6. Nov/2023/Paper_ 9701/12/No.20

Four mixtures are added to four separate 50 cm^3 samples of water and stirred.

Which mixture results in a solution with the highest pH?

A 1.0 g of aluminium oxide and 1.0 g of aluminium chloride

B 1.0 g of magnesium oxide and 1.0 g of magnesium chloride

C 1.0 g of phosphorus oxide and 1.0 g of phosphorus chloride

D 1.0 g of silicon dioxide and 1.0 g of silicon chloride

7. Nov/2023/Paper_ 9701/22/No.1

The elements silicon, phosphorus and sulfur are in Period 3 of the Periodic Table.

(a) (i) Describe the variation in atomic radius from silicon to sulfur.

..... [1]

(ii) The melting point of silicon is 1410 °C. The melting point of sulfur is 113 °C.

Explain this difference.

.....

.....

.....

..... [3]

(b) Table 1.1 shows some properties of the elements Si to S.

The first ionisation energy of P is **not** shown.

Table 1.1

property	Si	P	S
total number of electrons in s subshells			
total number of electrons in p subshells			
first ionisation energy / kJ mol^{-1}	786		1000
formula of most common chloride	$SiCl_4$	PCl_5	SCl_2

(i) Complete Table 1.1 to show the total number of s and p electrons in an atom of Si, P and S.

[2]

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

..... [1]

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(iii) Three possible values for the first ionisation energy of P are given.

619 kJ mol^{-1} **893 kJ mol^{-1}** **1060 kJ mol^{-1}**

Circle the correct value.

Explain your choice, including a comparison of your chosen value to those of Si and S.

.....

.....

.....

.....

.....

..... [4]

(iv) $SiCl_4$ and PCl_5 each react with water, forming misty fumes.

Identify the chemical responsible for the misty fumes.

..... [1]

(v) Predict the shape of the SCl_2 molecule.

..... [1]

[Total: 13]

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8. June/2023/Paper_9701/11/No.12

Four successive ionisation energies (IE) of element E are shown.

Element E is in Period 3 of the Periodic Table.

fifth IE / kJ mol^{-1}	sixth IE / kJ mol^{-1}	seventh IE / kJ mol^{-1}	eighth IE / kJ mol^{-1}
16 000	20 000	24 000	29 000

In which group of the Periodic Table is E?

A 14 **B** 15 **C** 16 **D** 17

9. June/2023/Paper_9701/11/No.18

SiO_2 has a melting point of 1713 °C. It reacts with hot NaOH(aq) to form sodium silicate, Na_2SiO_3, and water.

No reaction occurs when SiO_2 is added to hot H_2SO_4(aq).

What can be deduced from this information?

	chemical behaviour of SiO_2	structure of SiO_2
A	amphoteric	giant
B	amphoteric	simple
C	acidic	giant
D	acidic	simple

10. June/2023/Paper_9701/11/No.19

Element X has the second largest atomic radius in its period. An atom of X has three occupied electron shells only.

The oxide of X is shaken with water.

What could be the pH of the resulting solution?

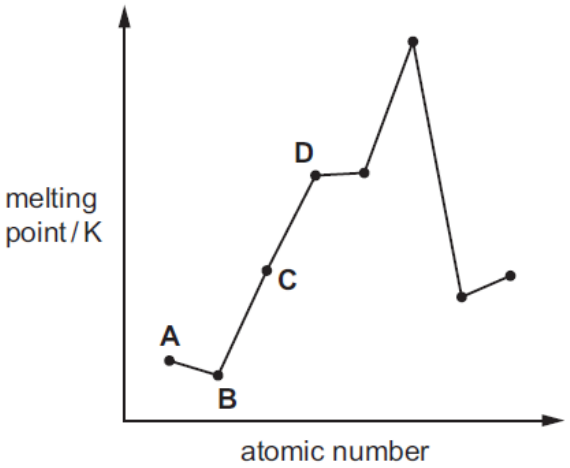
A 5 **B** 7 **C** 9 **D** 14

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11. June/2023/Paper_9701/11/No.21

The diagram shows the melting points of eight elements with consecutive atomic numbers.

Which element could be sodium?



12. June/2023/Paper_9701/12/No.17

L, M and N are three different elements from Period 3 of the Periodic Table.

L is the element whose atoms have three unpaired electrons in its 3p sub-shell.

M is the element with the highest electrical conductivity in the period.

N is the element with the highest melting point in the period.

Which statement about element L is correct?

A L has a higher atomic number than M and a lower atomic number than N.

B L has a lower atomic number than M and a higher atomic number than N.

C L has a lower atomic number than both M and N.

D L has a higher atomic number than both M and N.

13. June/2023/Paper_9701/12/No.18

In reactions 1 and 2, X represents an element in Period 3.

In each reaction, X is forming a product where X is in its highest oxidation state.

reaction 1 chlorine + element X $\rightarrow$ X_yCl_z

reaction 2 oxygen + element X $\rightarrow$ X_pO_q

Which ratios show a steady increase from sodium to phosphorus?

A neither z : y nor q : p

B z : y only

C q : p only

D both z : y and q : p

14. June/2023/Paper_9701/12/No.19

Sodium, magnesium, aluminium, silicon and phosphorus are all elements in Period 3 of the Periodic Table.

Three statements about the oxides and chlorides of these elements are given.

1 The ionically bonded oxides all react with dilute hydrochloric acid.

2 All metal chlorides produce neutral solutions when added to water.

3 The two most electronegative elements both form covalently bonded chlorides.

Which statements are correct?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

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15.

The elements magnesium and phosphorus are reacted separately with an excess of oxygen to form their oxides. Each oxide is then added separately to water and the pH values of the resulting solutions are measured.

The same two elements are reacted separately with an excess of chlorine to form their chlorides. Each chloride is then added separately to water and the pH values of the resulting solutions are measured.

Which row is correct?

	oxide giving the higher pH	chloride giving the higher pH
A	magnesium	magnesium
B	magnesium	phosphorus
C	phosphorus	magnesium
D	phosphorus	phosphorus

16. March/2023/Paper_9701/12/No.19

Two Period 3 elements, X and Y, burn separately in oxygen to form solid oxides.

The oxide of X is insoluble in water.

The oxide of Y dissolves in water to form a solution which dissolves the oxide of X.

What could X and Y be?

	X	Y
A	aluminium	sodium
B	magnesium	sodium
C	silicon	phosphorus
D	silicon	sulfur

17. March/2023/Paper_9701/12/No.20

Which row describes the structure and bonding of SiO_2 and $SiCl_4$?

	SiO_2		$SiCl_4$	
	structure	bonding	structure	bonding
A	giant	covalent	giant	covalent
B	giant	covalent	simple	covalent
C	giant	ionic	giant	covalent
D	giant	ionic	simple	covalent

18. March/2023/Paper_9701/12/No.22

V and Z are both elements in Period 3 of the Periodic Table. Each element forms one stable ion that does not contain another element.

The atomic radius of each element and the ionic radius of the ion described above is shown.

element	atomic radius / nm	ionic radius / nm
V	0.186	0.095
Z	0.099	0.181

Which statement is correct?

A Ions of V and Z have the same number of full electron shells.

B Ions of Z are positively charged.

C Z has a greater electronegativity than V.

D V has more outer electrons than Z.

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