PEARSON EDEXCEL IAL CHEMISTRY · YCH11

CHEMISTRY



EXAM QUESTION PACK

UNIT 1: METALLIC BONDING

SCORE	PERCENTAGE
/79	%

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Q1.

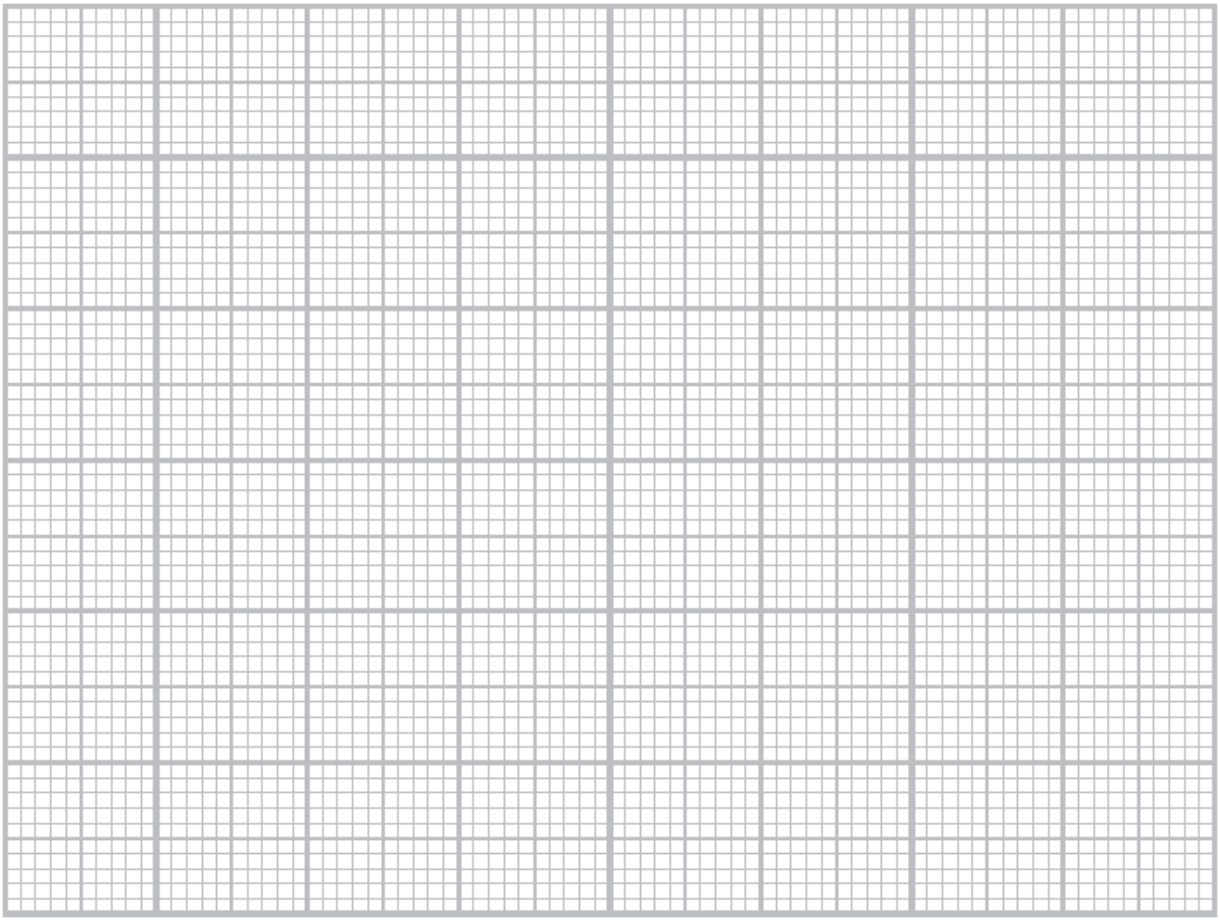
This question is about the elements in Period 3 of the Periodic Table, and some of their compounds.

(a) The atomic radii of six of the elements are given.

Symbol	Na	Mg	Al	Si	P	S	Cl	Ar
Atomic number	11	12	13	14	15	16	17	18
Atomic radius / nm	0.191	0.160	0.130			0.102	0.099	0.095

(i) Plot a graph of atomic radius against atomic number.

(2)



(ii) Use the graph to estimate the atomic radius of silicon, Si.

(1)

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(iii) Suggest an explanation for the decrease in atomic radius as atomic number increases across a period.

(3)

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(b) The melting temperatures of sodium, sodium chloride and chlorine are given in the table.

Complete the table to show the type of structure, the type of bond or force broken on melting and the particles involved.

(6)

Substance	Sodium	Sodium chloride	Chlorine
Melting temperature / °C	98	801	−101
Type of structure	giant		simple molecular
Type of bond or force broken on melting			
Particles involved			chlorine molecules

(c) Solid phosphorus(V) chloride contains PCl_4^+ ions.

(i) Draw a dot-and-cross diagram of a PCl_4^+ ion.

Show only outer shell electrons.

(1)

(ii) Predict the shape of a PCl_4^+ ion.

Justify your answer.

(3)

Shape .....

Justification

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(Total for question = 16 marks)

Q2.

This question is about bonding.

(a) Draw an electron density map for a molecule of oxygen.

(1)

(b) Draw a diagram to show the shape of a water molecule.

Give the bond angle.

(2)

Bond angle .....

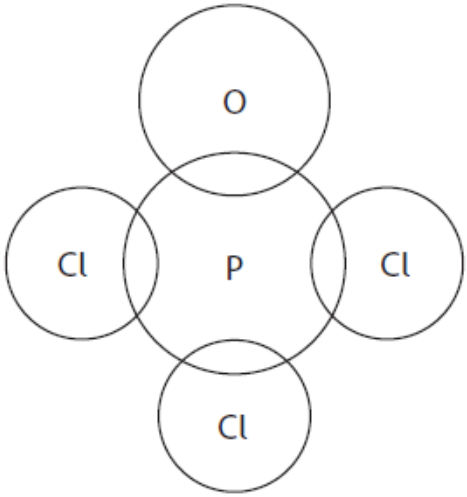
(c) The compound $POCl_3$ has a simple molecular structure.

(i) Complete the dot-and-cross diagram for the $POCl_3$ molecule.

Use crosses (✕) for the phosphorus electrons, dots (●) for the chlorine electrons

and circles (O) for the oxygen electrons.

(2)



(ii) Explain the shape of this molecule using the electron-pair repulsion theory.

(3)

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(d) The properties of metals depend on their structure and bonding.

(i) Draw a labelled diagram to show the metallic bonding in calcium.

(2)

(ii) Explain how the electrical conductivity, high melting temperature and malleability of metals depend on their structure and bonding.

(3)

Electrical conductivity.....

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High melting temperature
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Malleability .....

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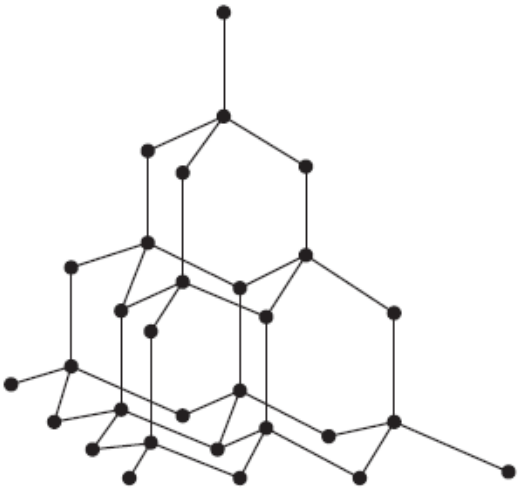
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(e) Diamond, graphite and graphene are all forms of carbon.

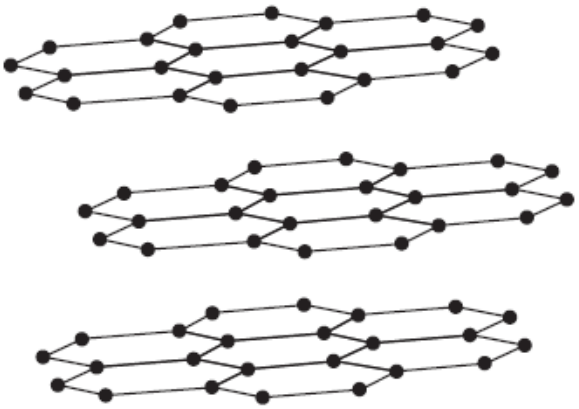
(i) Explain **two** ways in which the physical properties of diamond and graphite differ.

Refer to their structure and bonding in your answer.

(4)



diamond



graphite

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(ii) State how the structure of graphene is related to the structure of graphite.

(1)

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(iii) State a use for graphene, identifying the property that makes it suitable for that use.

(2)

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(Total for question = 20 marks)

Q3.

This question is about the bonding in the elements of Period 3 in the Periodic Table.

The melting temperatures of the Period 3 elements are shown in the table.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Melting temperature / °C	98	650	660	1423	44	120	–101	–189

(a) Sodium, magnesium and aluminium are metals.

(i) State what is meant by metallic bonding.

(1)

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(ii) Melting temperature depends on the strength of metallic bonding.

Explain why the metallic bonding in magnesium is much stronger than that in sodium.

(3)

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(b) (i) In the elements silicon, phosphorus, sulfur and chlorine, the atoms are joined by covalent bonds.

Describe the attraction between the atoms in a covalent bond.

(1)

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(ii) Explain why the melting temperature of silicon is much higher than that of phosphorus, by referring to their structures.

(3)

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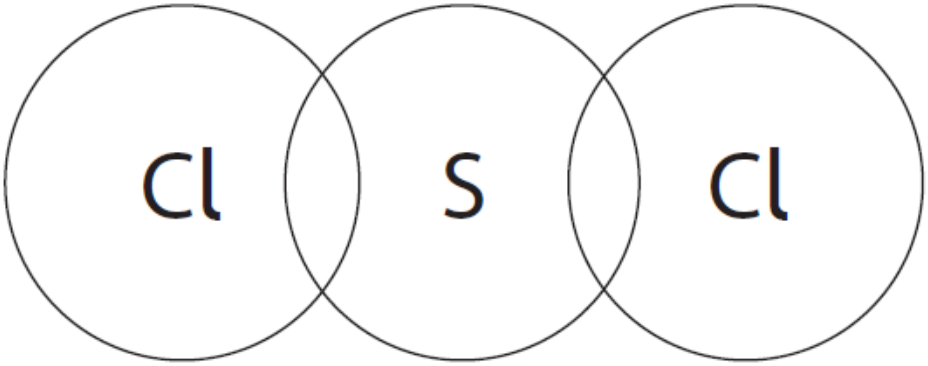
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(c) Sulfur reacts with chlorine to form sulfur dichloride, SCl_2.

(i) Complete the dot-and-cross diagram of a molecule of sulfur dichloride. Use dots (•) for the

chlorine electrons and crosses (×) for the sulfur electrons. Show the outer shell electrons only.

(2)



(ii) Suggest a value for the Cl—S—Cl bond angle. Justify your answer.

(3)

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(Total for question = 13 marks)

Q4.

Metallic bonding is the strong electrostatic attraction between

☒ **A** anions and cations

☒ **B** atoms and delocalised electrons

☒ **C** ions and delocalised electrons

☒ **D** two nuclei and a shared pair of electrons

(Total for question = 1 mark)

Q5.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Covalent bonding is best described as the electrostatic attraction between

☒ **A** oppositely charged ions

☒ **B** positive ions and delocalised electrons

☒ **C** a shared pair of electrons

☒ **D** two nuclei and a shared pair of electrons

(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Which of these has the **greatest** electrical conductivity?

☒ **A** $SF_6(g)$

☒ **B** $H_2O(l)$

☒ **C** $Hg(l)$

☒ **D** $Na_2O(s)$

(Total for question = 1 mark)

Q7.

Aluminium is an abundant metal with many uses.

(a) The first four ionisation energies of aluminium are shown.

Ionisation number	Energy / kJ mol^{-1}
1	578
2	1820
3	2750
4	11 600

Explain how this information shows that aluminium is in Group 3 of the Periodic Table.

(2)

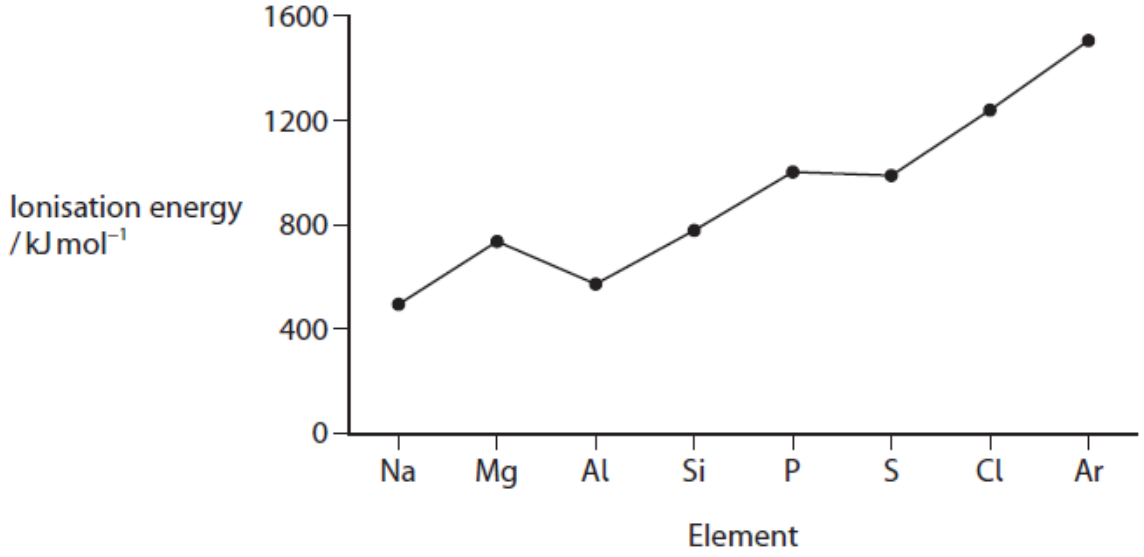
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(b) The graph shows the first ionisation energies for the elements in Period 3.



(i) Explain the general increase in the first ionisation energy from sodium to argon.

(2)

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(ii) Explain why the first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

(2)

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(c) (i) Describe the bonding in aluminium metal.

(2)

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(ii) Give two possible reasons why aluminium is used for overhead power cables.

(2)

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(d) New uses for waste aluminium cans are being investigated. One possible use is to make nanoparticle alloys to produce hydrogen for fuel.

(i) Aluminium nanoparticles react with water to produce aluminium oxide and hydrogen.

Complete the following equation. State symbols are not required.

(1)

..... Al + ... H_2O → ..... + ...

(ii) Give **two** possible reasons for producing hydrogen from aluminium rather than from fossil fuels.

(2)

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(Total for question = 13 marks)

Q8.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Some physical properties of five substances are shown.
The letters are **not** element symbols.

Substance	Electrical conductivity			Melting temperature /°C
	Solid	Liquid	Solution in water	
L	poor	good	good	770
M	good	good	reacts	98
N	good	good	insoluble	1083
P	poor	poor	insoluble	113
Q	poor	poor	good	10

(a) Which of these substances could be metals?

☒ **A** N only

☒ **B** L and M only

☒ **C** M and N only

☒ **D** L, M and N only

(b) Which substance has properties showing that it changes from a molecular structure to ions when it dissolves in water?

☒ **A** L

☒ **B** M

☒ **C** P

☒ **D** Q

(Total for question = 2 marks)

Q9.

Magnesium is a metal in Group 2 of the Periodic Table. It reacts with chlorine to form the salt magnesium chloride, $MgCl_2$.

(a) Draw a dot-and-cross diagram for magnesium chloride.

Show outer shell electrons only.

(1)

(b) Magnesium conducts electricity when it is in the solid state. Magnesium chloride conducts electricity when it is molten or dissolved in water but not when it is in the solid state.

Explain these observations.

(3)

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(c) Magnesium chloride can also be made by reacting magnesium oxide with dilute hydrochloric

acid.

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

(i) Write the **ionic** equation, including state symbols, for this reaction.

(1)

(ii) Calculate the minimum volume of 2.00 mol dm^{-3} hydrochloric acid needed to completely react with 2.45 g of magnesium oxide.

(3)

Minimum volume of hydrochloric acid = ... cm^3

(d) A further method for making magnesium chloride is by reacting magnesium carbonate with dilute hydrochloric acid.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

Calculate the maximum mass of magnesium chloride that could be formed when 2.25 g of magnesium carbonate is added to excess dilute hydrochloric acid.

(2)

Maximum mass magnesium chloride = ... g

(e) Explain why the reaction to make magnesium chloride from magnesium oxide has a higher atom economy than the reaction using magnesium carbonate.

No calculation is required.

(2)

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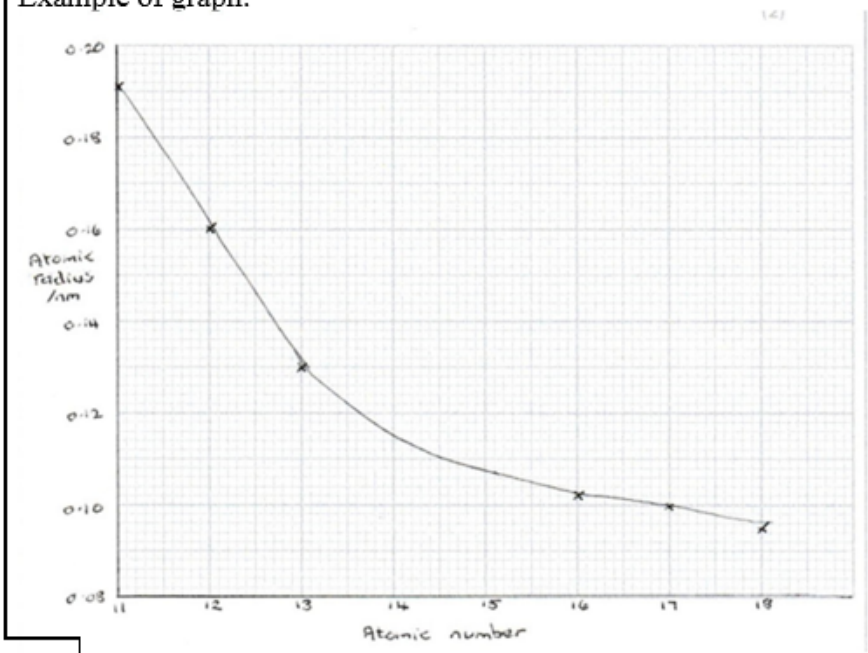
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(Total for question = 12 marks)

Mark Scheme

Q1.

Q	Answer	Additional guidance	Mark
(a)(i)	Example of graph:  		2
	• axes correct and labelled with atomic radius /nm and atomic number **(1)**	Allow y axis with 191 etc and label as pm or x 10^{-3} nm Ignore symbols on x axis Do not award M1 if x axis scale starts at 0	
	• points plotted correctly **(1)**	The points for Si / atomic number 14 and P / atomic number 15 do not need to be marked Accept graph with or without line drawn **Comment** If atomic radius is plotted on the x axis, allow (1) for correct graph	

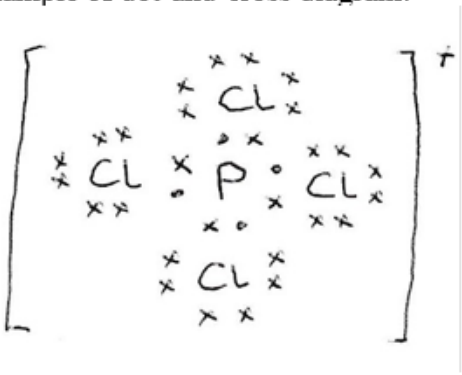
Q	Answer	Additional guidance	Mark
(a)(ii)	• value in allowed range	Allow 0.112 to 0.118 (nm) Allow value written in table Ignore any value given for phosphorus	1

Q	Answer	Additional guidance	Mark
(a)(iii)	An explanation that makes reference to the following points: • (as the atomic number increases / across the period) the nuclear charge increases / the number of protons (in the nucleus) increases **(1)** **Any two from:** • this is only partially offset by the increased electron (-electron) repulsion as the number of electrons in the (outer) shell increases **(1)** • the electrons are all the same (quantum) shell / experience similar shielding **(1)** • so there is an increase in attractive force between the nucleus and (outer) electrons **(1)**	Allow effective nuclear charge increases Allow the same amount of shielding Allow same number of (occupied quantum) shells Do not award electrons in the same subshell / orbital	**3**

Q	Answer	Additional guidance	Mark
(b)	• giant for structure of sodium chloride **(1)** • metallic bonding for sodium **(1)** • ionic bonding for sodium chloride **(1)** • intermolecular (forces) for chlorine **(1)** • Na^+ **and** electrons / cations **and** electrons (particles in sodium) **(1)** • Na^+ **and** Cl^- /cations **and** anions (particles in sodium chloride) **(1)**	Allow giant ionic / (giant) lattice Ignore metal Ignore ion(s) Ignore electrostatic attractions in M2 and M3 Accept London / dispersion (forces) Allow van der Waals' (forces) Ignore weak (forces) Allow positive ions **and** electrons Allow sodium atoms / ions **and** electrons Allow positive (sodium) ion and negative (chloride / chlorine) ion Ignore just sodium ions and chloride ions Penalise incorrect charge on an ion once only e.g. Na^{2+}	**6**

Example of table:

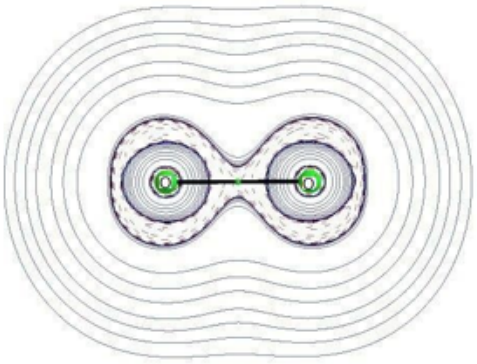
Substance	Sodium	Sodium chloride	Chlorine
Melting temperature /°C	(98)	(801)	(−101)
Type of structure	(giant)	giant	(simple molecular)
Type of bond or force broken on melting	metallic	ionic	intermolecular forces
Particles involved	Na^+ **and** electrons / cations **and** electrons	Na^+ **and** Cl^- /cations **and** anions	(chlorine molecules)

Q	Answer	Additional guidance	Mark
(c)(i)	• correct dot-and-cross diagram	Example of dot-and-cross diagram:  Allow any combination of dots and crosses, including all dots or all crosses Allow overlapping circles Allow electrons in bonds along the axis of the bond Ignore missing bracket and charge Ignore lines representing covalent bonds e.g. x	1

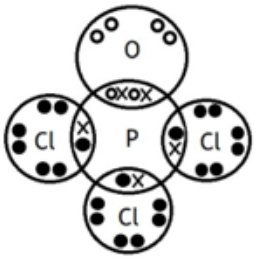
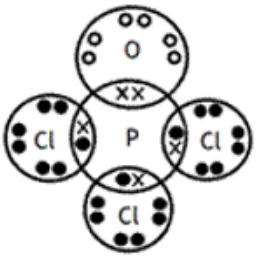
Q	Answer	Additional guidance	Mark
(c)(ii)	• Shape – tetrahedral **(1)** • Justification – (four) bonding pairs /pairs of electrons (around P) **(1)** • (electron pairs) arranged to minimise repulsion **(1)**	Stand alone No TE on (c)(i) for shape Allow the number of electron pairs shown in (c)(i) Allow regions of electron density for electron pairs Ignore reference to lone pair-lone pair / lone pair-bond pair repulsion Allow (electron pairs) arranged for maximum separation / as far apart as possible Ignore electron pairs repel equally Penalise use of bonds for electron pairs once only in M2 and M3	3
			(Total for Question = 16 marks)

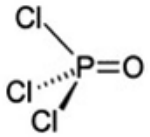
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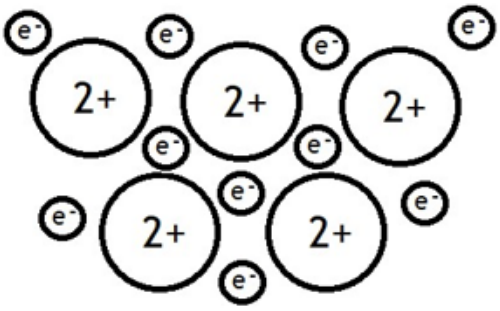
Q2.

Question Number	Answer	Additional guidance	Mark
(a)	A sketch showing: • two atoms with high electron density and a symmetrical cloud around both	e.g.  At least one separate circle around each atom **and** at least one contour line with an indentation above and below the axis **and** circling both atoms ie  is the minimum Allow nuclei shown as + signs Allow dashed contour lines	**(1)**

Question Number	Answer	Additional guidance	Mark
(b)	A diagram that includes: • shape of H_2O **(1)** • bond angle **(1)**	CHECK THE ANSWER LINE ON BOTTOM RIGHT CORNER! (as well as angles on diagram)  Allow dot-cross diagrams if in the correct shape Allow 3D representations showing lone pairs Ignore the presence of lone/bonding pairs of electrons Ignore charges or partial charges even if incorrect Do not award double bonds Accept bond angle from 104° to 105 ° Allow bond angle labelled <u>correctly</u> on diagram Do not award M2 if one correct and one incorrect bond angle stated	**(2)**

Question Number	Answer	Additional guidance	Mark
(c)(i)	A diagram that includes: • phosphorus singly covalently bonded to three chlorine atoms and three lone pairs on each chlorine **(1)** • phosphorus doubly bonded to an oxygen atom and two lone pairs on the oxygen or a dative covalent bond from the phosphorus and three lone pairs on the oxygen **(1)**	 OR  Penalise absence of lone pairs once only Allow lone pairs to appear as separate electrons Allow any representation of electrons **but** electrons in a dative covalent bond must appear to be the same	**(2)**

Question Number	Answer	Additional guidance	Mark
(c)(ii)	An answer that makes reference to the following points: • (based on) tetrahedron / tetrahedral (arrangement) **(1)** • four regions of bonding electrons **(1)** • adopt the positions of minimum repulsion **(1)**	MP1 can be given for a 3-D diagram  Accept 5 bonding pairs, where two (in double bond) behave as one. Allow 4 bonding pairs Allow phosphorous bonds to 4 other atoms Accept repel to maximum separation Allow maximise the distance between the bonding pairs Allow to achieve lowest (potential) energy state Ignore to become most stable Do not award maximum repulsion Ignore bond angles throughout Ignore lone pairs throughout	**(3)**

Question Number	Answer	Additional guidance	Mark
(d)(i)	A diagram that includes:	The diagram must include at least four ions in two rows 	(2)
	• positive (2+) ions / cations **(1)**	Accept 1+ ions Accept close packed ions Allow +1/+2 (oxidation state instead of charge)	
	• surrounded by randomly arranged delocalised electrons with approximately equal positive and negative charges **(1)**	Accept reference to "sea of electrons" Allow "e" or "–" to represent electrons Ignore "electron cloud"	

Question Number	Answer	Additional guidance	Mark
(d)(ii)	An explanation that makes reference to the following points: Electrical conductivity: • the <u>electrons</u> can flow (under a potential difference) **(1)** High melting temperature: • <u>strong</u> force of attraction between the (positive) ions and electrons **(1)** Malleability: • the ions can <u>slide</u> past each other (while still being held together by the electrons) **(1)**	Accept "move" Accept "carry charge/current" Allow "mobile" "Delocalised electrons" alone is insufficient Allow bond strength instead of force of attraction Allow metallic bonds are <u>strong</u> Do not award protons instead of cations Do not award negative ions instead of electrons Do not award strong intermolecular bonds Accept ions can <u>move over</u> each other Allow atoms/layers slide over each other Ignore "mobile ions"	**(3)**

Question Number	Answer	Additional guidance	Mark
(e)(i)	An explanation that makes reference to the following points: • diamond is hard **and** graphite is soft **(1)** • because diamond has a rigid lattice / weak forces between the layers in graphite (allow the layers to slide over one another) **(1)** • graphite conducts (electricity) **and** diamond does not **(1)** • because graphite has delocalised electrons (which are free to move) / diamond does not **(1)**	Ignore strong in place of hard Accept "diamond has covalent bonds in a 3D structure" Ignore diamond has a tetrahedral structure Accept that electrons are free to move in graphite Allow free electrons Marks are independent. I.e. Comments on properties without comparison score 2 for MP2 and MP4. Ignore additional properties e.g. melting temperature	**(4)**

Question Number	Answer	Additional guidance	Mark
(e)(ii)	• single layer / monolayer	Accept "one atom thick layer" Allow "graphene is one layer of graphite" or "individual layer of graphite" Ignore references to the structures and bonding of graphite and graphene Do not award "thin sheet of graphite" NB Assume "it" refers to graphene	(1)

Question Number	Answer	Additional guidance	Mark
(e)(iii)	• potential use (1) • (use linked to) at least one property (1)	Examples: • flexible electronics • as only one atom thick or conducts electricity or • transparent electrodes scores • as only one atom thick or conducts electricity or • oxidation resistant layer • as is unreactive or • data storage • as is lightweight or conducts electricity or is durable Marks are independent but to score 2, the property must have a plausible link to the named application Ignore lubricant Ignore used as electric wires Do not award reference to: • pencils as a use • making carbon brushes as a use • electrodes as a use (without a small size reference) • layers as a property	(2)

Example uses of Graphene (non-exhaustive!)
• added to other materials e.g. drill tips, roads, bullet proof clothing, body armour • heat sinks e.g. thermal foils for mobile phones • coatings on spacecraft • microelectronics • (small) batteries • supercapacitors • enhancing fuel cells • non-stick coatings e.g. do not allow just "frying pan" • anti-corrosion coatings or paints e.g. for self-healing pipes, NB do not allow "aeroplanes" or "industrial equipment" without qualification • efficient and precise sensors • faster electronics • micro electrodes • flexible displays • touchscreens / mobile (phone) screen • solar panels / photo(voltaic) cells • making nanotubes • composites • microtubules or microfibres in drug delivery / medicine • low friction coatings • used to make electric wires

Properties of graphene
• thin • flexible • transparent • oxidation resistant • reduces friction between surfaces • low density • high melting point • durable • strong • thermal conductor • electrical conductor • can be made into nanotubes
(Total for Question = 20 marks)

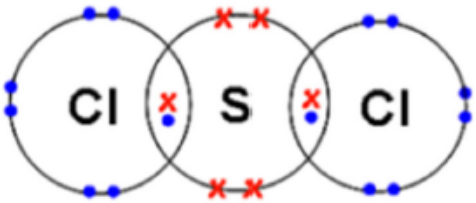
Q3.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	• (metallic bonding is) the **attraction** between positive ions/cations and **delocalised** electrons	Can be shown as a labelled diagram including the word **attraction.** Allow **electrostatic forces** as an alternative to **attraction** Allow **attraction** between metal ions and **delocalised** electrons Allow **attraction** between (positive) nuclei and **delocalised** electrons Ignore just 'ions' Ignore free moving electrons/ sea of electrons	**(1)**

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	An explanation that makes reference to three of the following points • M1 Mg has more **delocalised** electrons **(1)** • M2 **Mg^{2+}** is smaller (than Na^+) **(1)** • M3 **Mg^{2+}** has a higher charge (than Na^+) **(1)** • M4 Greater attraction between the **delocalised** electrons and the Mg^{2+} ions/ Mg^{2+} nuclei **(1)**	Allow Mg loses two electrons **and** Na one to form **delocalised** electrons Ignore free moving electrons Allow Mg ion is smaller (than Na^+) Allow Mg smaller ionic radius Do not award atomic radius Allow Mg ion has a higher charge (than Na^+) Ignore the number of protons Just Mg^{2+} 'has a greater charge density' scores (1) for M2 & M3 Allow greater attraction between the delocalised electrons and Mg Ignore attraction to the protons Ignore outer shell electrons Allow reverse argument for all points	**(3)**

Question Number	Answer	Additional Guidance	Mark
(b)(i)	• (the electrostatic attraction between) the shared (pair of) electrons and the (two) nuclei (of the bonded atoms)	Allow single nucleus	**(1)**

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	An explanation that makes reference to the following points: • phosphorus (P) simple molecular (1) • silicon (Si) giant (covalent/molecular) structure (1) • when phosphorus melts weak London forces are broken **and** when silicon melts strong covalent bonds are broken (1)	Allow (small) molecules/ P_4/ just 'molecular'/simple covalent Allow lattice instead of giant Ignore macromolecular Do not award giant metallic/ionic Allow / dispersion /van der Waals forces/ instantaneous dipole-induced dipole/intermolecular forces Do not award if any mention of intermolecular forces for silicon.	(3)

Question Number	Answer	Additional Guidance	Mark
(c)(i)	An explanation that makes reference to the following points: • dot-and-cross diagram showing two shared pairs of electrons between S and Cls (1) • rest of diagram correct (1)	Example of dot-and-cross diagram  Allow all dots/all crosses/dots crosses the wrong way round Allow the non-bonded pairs of electrons on S and Cl anywhere and allow non-bonding electrons unpaired. Ignore inner shells Charged species/ions scores 0	(2)

Question Number	Answer	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to the following points: • bond angle 104.5(°) (1) • four pairs of electrons/ 2 bonding pairs and 2 lone pairs occupy a position of minimum repulsion (1) • (2)lone pairs repel more than bonding pairs (so the angle is reduced from 109.5 (°)) (1)	Allow 102-105 (actual answer 103°) Allow just electron pairs occupying a position of minimum repulsion and do not penalise for an incorrect number of electron pairs if quoted. Allow maximum separation Ignore bonds/ areas of electron density/atoms Ignore any reference to shapes e.g. angular, V-shaped	(3)

Q4.

Question number	Answer	Mark
	The only correct answer is C (ions and delocalised electrons) ***A*** *is incorrect because this is ionic bonding* ***B*** *is incorrect because atoms do not attract delocalised electrons* ***D*** *is incorrect because this is covalent bonding*	**(1)**

Q5.

Question Number	Answer	Mark
	The only correct answer is D (two nuclei and a shared pair of electrons) **A** *is not correct because this describes ionic bonding* **B** *is not correct because this describes metallic bonding* **C** *is not correct because electrons do not attract one another*	**(1)**

Q6.

Question number	Answer	Mark
	The only correct answer is C (Hg(l)) ***A*** *is incorrect because simple molecules do not conduct electricity* ***B*** *is incorrect because simple molecules do not conduct electricity* ***D*** *is incorrect because ionic compounds do not conduct electricity as solids*	**1**

Q7.

Question Number	Answer	Additional Guidance	Mark
(a)	• there is a "jump"/much bigger increase between the third and fourth ionisation energies **(1)** • (First) 3 electrons in outer shell **(1)**	Accept fourth electron is removed from a different (quantum) **shell** (which is closer to the nucleus)	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)(i)	• the number of protons increases /nuclear charge increases **(1)** • the additional electrons are in the same shell/same energy level/ little additional shielding from electrons **(1)**	Allow "same shielding" Ignore references to atomic radius even if incorrect Ignore electron repulsion	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	• the first electron is removed from a (3)p orbital/subshell in aluminium/ (3)s orbital/subshell from magnesium **(1)** • p electron(s) shielded by the s electrons (so requires less energy)/ p energy level is higher than s energy level **(1)**	Do not award 2p/2s	**(2)**

Question Number	Answer	Additional Guidance	Mark
(c)(i)	An answer that makes reference to • delocalised /free (to move) electrons /sea of electrons **(1)** • attracted to (a lattice of) metal/aluminium/positive **ions/cations** **(1)**	Allow charges up to 3+ Correct fully labelled diagram scores 2 marks Ignore attraction of electrons to nuclei	**(2)**

Question Number	Answer	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to **two** of the following: • (delocalised) electrons can move/carry charge **(1)** • aluminium has low density/light (weight) **(1)** • aluminium is ductile/can be drawn into wires **(1)** • aluminium forms an inert/oxide layer	Allow good conductor of **electricity** Ignore malleable, strong, heat resistant, high melting temperature.	**(2)**

Question Number	Answer	Additional Guidance	Mark
(d)(i)	**2** Al + **3** H_2O → Al_2O_3 + $3H_2$	Allow multiples Ignore state symbols even if incorrect	**(1)**

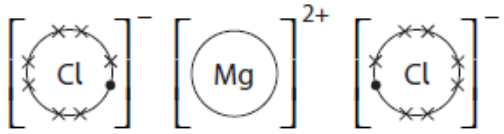
Question Number	Answer	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to **two** of the following: • reduces greenhouse gas emissions / carbon dioxide **and** which affects climate change / global warming **(1)** **(1)** • the production of hydrogen is portable **(1)** • fossil fuels are non-renewable (unlike water) **(1)** • aluminium can be recycled	Allow reduces sulfur dioxide emissions **and** which reduces acid rain Do not award references to ozone depletion, carbon neutral Ignore renewable Ignore landfill, atom economy, references to cost	**(2)**

Q8.

Question number	Answer	Mark
(a)	**The only correct answer is C** (M and N only) ***A*** *is not correct because M is also a metal* ***B*** *is not correct because L cannot be a metal because it is a poor conductor in the solid state* ***D*** *is not correct because L cannot be a metal because it is a poor conductor in the solid state*	1

Question number	Answer	Mark
(b)	**The only correct answer is D** (Q) ***A*** *is not correct because L conducts in the liquid state* ***B*** *is not correct because M conducts in the solid and liquid states* ***C*** *is not correct because P does not dissolve in water*	1

Q9.

Question number	Answer	Additional guidance	Mark
(a)	• dot-and-cross diagram, including charges	Example of diagram:  Allow no electrons or 8 electrons on outer shell of Mg Allow any combination of dots or crosses for electrons Ignore missing square brackets	1

Question number	Answer	Additional guidance	Mark
(b)	An explanation that makes reference to the following points: • identification of charge carriers: magnesium - electrons **and** magnesium chloride - ions (1) • magnesium conducts electricity when solid because delocalised electrons can flow through (1) • magnesium chloride does not conduct when solid because the ions cannot move **and** it does conduct electricity when molten or dissolved in water as the ions can move. (1)		3

Question number	Answer	Additional guidance	Mark
(c)(i)	• correct balanced ionic equation with state symbols	Examples of equation: $MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$ or $MgO(s) + 2H_3O^+(aq) \rightarrow Mg^{2+}(aq) + 2H_2O(l)$	1

Question number	Answer	Additional guidance	Mark
(c)(ii)	• calculation of moles of MgO (1) • calculation of moles of HCl (1) • calculation of volume of HCl (1)	Example of calculation: moles MgO = $\frac{2.45}{40.3}$ = 0.060794 moles HCl = 2 × 0.060794 = 0.121588 volume HCl = 0.121588 × $\frac{1000}{2.00}$ = 60.794 cm^3 Ignore SF except 1 SF Allow use of A_r(Mg) = 24 (61.25 cm^3) Correct answer with no working scores full marks	3

Question number	Answer	Additional guidance	Mark
(d)	Either • calculation of moles of $MgCO_3$ (1) • calculation of mass of $MgCl_2$ (1) or • use of both molar masses (1) • calculation of mass of $MgCl_2$ (1)	Example of calculation: moles $MgCO_3$ = $\frac{2.25}{84.3}$ = 0.02669 mass $MgCl_2$ = 0.02669 × 95.3 = 2.5436 (g) or 84.3 g $MgCO_3$ makes 95.3 g $MgCl_2$ so 2.25 g $MgCO_3$ makes $\frac{95.3}{84.3}$ × 2.25 = 2.5436 (g) $MgCl_2$ Ignore SF except 1 SF Allow use of A_r(Mg) = 24 (2.5446 g) Correct answer with no working scores full marks	2

Question number	Answer	Additional guidance	Mark
(e)	An explanation that makes reference to the following points: • (in the reaction with magnesium oxide) there are fewer waste products/no carbon dioxide is released/water is the only waste product (1) • so the molar mass of all products is lower/the denominator of the equation for atom economy is lower (1) or • 1 mol of magnesium compound produces 1 mol of magnesium chloride (1) • but the M_r of magnesium carbonate is greater than the M_r of magnesium oxide/carbon dioxide is an additional waste product from magnesium carbonate. (1)	Ignore calculations Allow reverse arguments	2