

# **Chemistry A**

Advanced Subsidiary GCE

Unit **F321**: Atoms, Bonds and Groups

## **Mark Scheme for June 2013**

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.















All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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## 1. Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Noted but no credit given
	Repeat

## 2. Subject-specific Marking Instructions

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

<b>Annotation</b>	<b>Meaning</b>
<b>DO NOT ALLOW</b>	Answers which are not worthy of credit
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ECF</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	Or reverse argument

All questions must be annotated with a tick where the mark is given.

Additional pages/objects: You **must** annotate the additional pages (before Question 1) and the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use a suitable annotation (either ^ or SEEN).

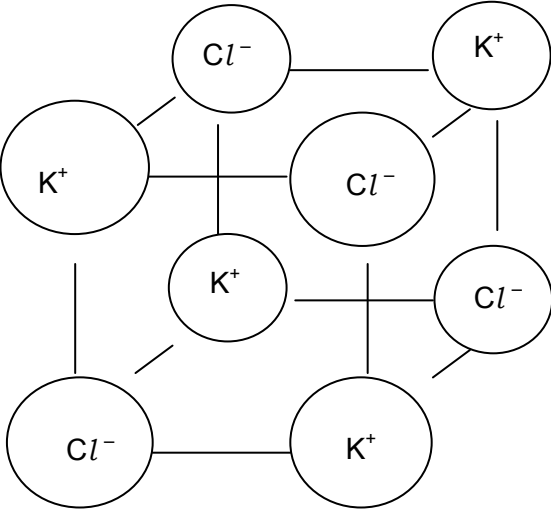
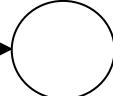
The following questions should be fully annotated with ticks, crosses and other relevant annotations to show where marks have been awarded in the body of the text:

3ai

4a

5ai

Question			Answer	Marks	Guidance
1	(a)	(i)	<p>Mass of the <b>isotope</b> compared to 1/12th <b>OR</b> mass of the <b>atom</b> compared to 1/12th ✓</p> <p>(the mass of an atom of) <math>^{12}\text{C}</math> ✓</p>	2	<p><b>ALLOW</b> for <math>^{12}\text{C}</math>: carbon-12 <b>OR</b> C-12 <b>OR</b> C 12 <b>OR</b> 12C</p> <p><b>ALLOW</b> mass of a <b>mole</b> of the isotope <b>OR</b> mass of a mole of atoms compared to 1/12th the mass of <b>mole</b> or 12 <b>g</b> of <math>^{12}\text{C}</math> for two marks</p> <p><b>ALLOW</b> mass of the isotope or mass of the atom compared to <math>^{12}\text{C}</math> which has a mass of 12(.0) for two marks</p> <p><b>ALLOW</b> one mark for responses which have individual atoms compared to one mole of 12C and vice versa eg mass of the isotope or mass of the atom compared to <math>^{12}\text{C}</math> which has a mass of 12(.0) <b>g</b> eg mass of an atom compared to 1/12th mass of one mole of <math>^{12}\text{C}</math> eg mass of one mole of atoms compared to 1/12th the mass of an atom of 12C</p> <p><b>ALLOW</b> 2 marks for responses expressed as a fraction eg <math>\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of } ^{12}\text{C}}</math></p> <p><b>IGNORE</b> (weighted) mean <b>OR</b> average</p> <p><b>DO NOT ALLOW</b> mass of element or mass of ion</p>
		(ii)	<p>19p and 20n ✓ <math>^{41}\text{K}^+</math> and 19p ✓</p>	2	<p>Mark by row <b>ALLOW</b> 41K+</p>
	(b)		<p><math>(1s^2) 2s^2 2p^6 3s^2 3p^2</math> ✓</p>	1	<p><b>ALLOW</b> <math>1s^2</math> repeated <b>ALLOW</b> subscripts <b>AND</b> upper case etc</p>

Question	Answer	Marks	Guidance
1 (c) (i)	<p><b>First check the answer on the answer line.</b>  <b>If answer = <math>3.01 \times 10^{22}</math> award 3 marks</b></p> <p>170.1 ✓  <b>(ALLOW</b> in working shown as <math>28.1 + 35.5 \times 4</math>)</p> <p>Correctly calculates amount of molecules  <math>8.505 / 170.1 = 0.05(00)</math> mol ✓</p> <p>Correctly calculates number of molecules  <math>0.05 \times 6.02 \times 10^{23} = 3.01 \times 10^{22}</math> ✓</p>	3	<p><b>ALLOW</b> <math>0.301 \times 10^{23}</math> for three marks</p> <p>If there is an alternative answer, check to see if there is any ECF credit possible using working below.</p> <p><b>ALLOW</b> ECF from incorrect molar mass of <math>\text{SiCl}_4</math>  <b>ALLOW</b> 0.05(00) (mol) for two marks</p> <p><b>ALLOW</b> ECF for incorrect number of mol of <math>\text{SiCl}_4</math></p> <p><b>ALLOW</b> calculator value or rounding to 3 significant figures or more <b>BUT IGNORE</b> 'trailing' zeroes, eg 0.200 allowed as 0.2.</p> <p><b>DO NOT ALLOW</b> any marks for:  <math>8.505 \times 6.02 \times 10^{23} = 5.12 \times 10^{24}</math></p>
	<p>(ii)</p>  <p>4 K and 4 Cl correctly arranged ✓  4 K<sup>+</sup> and 4 Cl<sup>-</sup> correctly arranged ✓</p>	2	<p><b>ALLOW</b> the structure with <b>ALL</b> Cl<sup>-</sup> and K<sup>+</sup> transposed</p> <p><b>ALLOW</b> labels if seen outside circles but linked with an arrow  eg K<sup>+</sup> → </p>
<b>Total</b>	<b>10</b>		

Question			Answer	Marks	Guidance
2	(a)	(i)	Al <sup>3+</sup> ✓ SO <sub>4</sub> <sup>2-</sup> ✓	2	
		(ii)	Al <sub>2</sub> O <sub>3</sub> (s) + 3H <sub>2</sub> SO <sub>4</sub> (aq) → Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> (aq) + 3H <sub>2</sub> O(l) Correct species <b>AND</b> correctly balanced ✓ state symbols on <b>correct</b> species ✓	2	<b>ALLOW</b> multiples
		(iii)	(The number of) water(s) of crystallisation ✓	1	<b>IGNORE</b> hydrated <b>OR</b> hydrous <b>OR</b> 'contains water'
		(iv)	<b>First check the answer on the answer line.</b> <b>If answer = 16, award 3 marks</b>  Correctly calculates amount of Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> : 6.846 / 342.3 = 0.02(00) mol ✓  Correctly calculates amount of H <sub>2</sub> O: 5.760 / 18.0 = 0.32(0) mol ✓  Correctly calculates whole number ratio of mol of H <sub>2</sub> O: Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> to give <b>x = 16</b> ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below  <b>ALLOW</b> as ECF from 12.606/342.3 = 0.0368(273) <b>AND</b> 0.32/0.0368(273) To give <b>x = 9</b> for two marks  <b>ALLOW</b> calculator value or rounding to 2 significant figures or more <b>BUT IGNORE</b> 'trailing' zeroes, eg 0.200 allowed as 0.2. <b>ALLOW</b> ECF for calculation of correctly rounded <b>whole number</b> value of H <sub>2</sub> O from incorrect mol of H <sub>2</sub> O and / or incorrect mol of Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> <b>BUT x</b> must be a whole number  <b>ALLOW</b> alternative method Mol of Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> : 6.846 / 342.3 = 0.02(00) mol (first mark)  Molar mass of Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · <b>x</b> H <sub>2</sub> O: 12.606 / 0.02(00) = 630.3 g mol <sup>-1</sup> (second mark)  Mass of water per mol = 630.3 – 342.3 = 288 <b>AND</b> 288/18 to give <b>x = 16</b> (third mark)

Question			Answer	Marks	Guidance
2	(b)	(i)	$Cl_2 + H_2O \rightarrow HCl + HClO$ ✓  H <sup>+</sup> ions are released <b>OR</b> HCl is acidic <b>OR</b> HClO is acidic ✓	2	<b>ALLOW</b> HOC/ <b>ALLOW</b> equilibrium sign <b>IGNORE</b> state symbols  <b>ALLOW</b> formulae <b>OR</b> names  <i>If correct equation is seen:</i> <b>ALLOW</b> 'product is acidic' <b>OR</b> 'acid is produced' <b>IGNORE</b> 'the solution is acidic' but <b>ALLOW</b> 'the solution formed is acidic' <b>DO NOT ALLOW</b> 'chlorine is acidic' ie acidity must be related to the product(s)  <i>If an incorrect equation is seen:</i> <b>ALLOW</b> second mark if H <sup>+</sup> <b>OR</b> HCl <b>OR</b> HClO is given as a product in the equation <b>AND</b> is stated as being acidic  <i>If no equation is seen:</i> <b>ALLOW</b> second mark if H <sup>+</sup> <b>OR</b> HCl <b>OR</b> HClO is produced <b>AND</b> is stated as being acidic
		(ii)	ClO <sup>-</sup> ✓	1	<b>ALLOW</b> OCl <sup>-</sup>
<b>Total</b>				<b>11</b>	



Question			Answer	Marks	Guidance
3	(a)	(i)	<p>P in P<sub>4</sub> is 0 <b>AND</b> in PH<sub>3</sub> is -3 <b>AND</b> in NaH<sub>2</sub>PO<sub>2</sub> is (+)1 ✓</p> <p>Phosphorus has been oxidised (from 0) to +1 ✓</p> <p>Phosphorus has been reduced (from 0) to -3 ✓</p>	3	<p><b>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</b></p> <p><b>ALLOW</b> oxidation states written above the equation if not seen in the text <b>BUT IGNORE</b> oxidation states written above the equation if seen in the text</p> <p><b>ALLOW</b> 3- <b>AND</b> 1+  <b>DO NOT ALLOW</b> ions  <b>DO NOT ALLOW</b> P<sup>3-</sup> in PH<sub>3</sub> <b>OR</b> P<sup>+</sup> in NaH<sub>2</sub>PO<sub>2</sub>  <b>DO NOT ALLOW</b> phosphide or phosphine or phosphate in place of phosphorus  <b>ALLOW</b> P or P<sub>4</sub> for phosphorus  <b>ALLOW</b> ECF for the second and third marks if <b>ONE</b> incorrect oxidation number is assigned but directional changes are correct eg P = 0 and -3 and +2 instead of 0 and -3 and +1.  <b>IGNORE</b> references to electron loss / gain</p> <p>If correct oxidation numbers are seen <b>ALLOW</b> second <b>AND</b> third marking points for:  'Phosphorus is oxidised to form NaH<sub>2</sub>PO<sub>2</sub>'  <b>AND</b>  'Phosphorus is reduced to form PH<sub>3</sub>'</p> <p><b>IF</b> neither second and third marks have been awarded <b>ALLOW</b> for <b>ONE</b> mark:  Phosphorus has been both oxidised and reduced  <b>OR</b>  Phosphorus's oxidation number has increased and decreased</p>

Question		Answer	Marks	Guidance
3	(a) (ii)	<p><b>First check the answer on the answer line.</b>  <b>If answer = 360 (cm<sup>3</sup>) award 2 marks</b></p> <p>Correctly calculates amount of P<sub>4</sub> = 1.86/124.0            = 0.015(0) mol ✓</p> <p>Correctly calculates volume of PH<sub>3</sub> = 0.015(0) x 24000 =            360 (cm<sup>3</sup>) ✓</p>	2	<p>If there is an alternative answer, check to see if there is any ECF credit possible using working below</p> <p><b>ALLOW</b> ECF for wrong amount of P<sub>4</sub> x 24000 for second mark  <b>ALLOW</b> one mark for (1.86/31.0) x 24000 = 1440</p> <p><b>DO NOT ALLOW</b> 2<sup>nd</sup> mark for 1.86 x 24000 = 44640  <b>ALLOW</b> calculator value or rounding to 2 significant figures or more <b>BUT IGNORE</b> 'trailing' zeroes, eg 0.200 allowed as 0.2.</p>
	(b)	4PH <sub>3</sub> + 8O <sub>2</sub> → P <sub>4</sub> O <sub>10</sub> + 6H <sub>2</sub> O ✓	1	<p><b>ALLOW</b> correct multiples  <b>IGNORE</b> state symbols</p>
	(c) (i)	The hydrogen <b>ions OR</b> H <sup>+</sup> <b>OR</b> protons (of phosphoric acid) are replaced by sodium <b>ions OR</b> Na <sup>+</sup> ✓	1	<p><b>ALLOW</b> Na ions <b>OR</b> positive ions replace H ions <b>OR</b> metal ions have replaced hydrogen ions <b>OR</b> protons</p> <p><b>DO NOT ALLOW</b> Na replaces H. Ions are key in either word or symbol form.  <b>DO NOT ALLOW</b> incorrect charge on Na ions (eg Na<sup>2+</sup>)</p>
	(ii)	Correctly calculates 0.100 x 15 / 1000 = 1.5(0) x 10 <sup>-3</sup> <b>OR</b> 0.0015(0) ✓	1	
	(iii)	22.5 ✓	1	<p><b>ALLOW</b> ECF from (ii)            Answer from (ii) x (3/0.2) x 1000</p>
	(d) (i)	hydrogen bonding ✓ Permanent dipole(–dipole interactions) ✓	2	

Question			Answer	Marks	Guidance
3	(d)	(ii)	the intermolecular forces are weaker in PH <sub>3</sub> ✓	1	<p><b>ALLOW</b> the energy needed to overcome the intermolecular forces in NH<sub>3</sub> is greater</p> <p>Check table in part (i)</p> <p><b>IF</b> NH<sub>3</sub> = hydrogen bonds <b>AND</b> PH<sub>3</sub> = permanent dipoles <b>OR</b> van der Waal's forces;  <b>ALLOW</b> 'Hydrogen Bonds are stronger' <b>ORA</b></p> <p><b>IF</b> NH<sub>3</sub> = permanent dipoles <b>AND</b> PH<sub>3</sub> = van der Waal's forces;  <b>ALLOW</b> 'permanent dipoles are stronger' <b>ORA</b></p> <p><b>IF</b> NH<sub>3</sub> = permanent dipoles <b>AND</b> PH<sub>3</sub> = permanent dipoles;  <b>ALLOW</b> 'permanent dipoles are stronger in NH<sub>3</sub>' <b>ORA</b></p> <p><b>DO NOT ALLOW</b> PH<sub>3</sub> has weaker vdW's than NH<sub>3</sub>  <b>DO NOT ALLOW</b> NH<sub>3</sub> has stronger hydrogen bonds than PH<sub>3</sub>  <b>DO NOT ALLOW</b> implication that covalent bonds are broken</p>
	(e)	(i)	Both electrons have been donated by one atom ✓	1	<p><b>ALLOW</b> 'they' for electrons  <b>IGNORE</b> elements for atom  <b>DO NOT ALLOW</b> 'transfer' in place of 'donated'  <b>DO NOT ALLOW</b> more than one electron pair is donated</p>

Question			Answer	Marks	Guidance
3	(e)	(ii)	<p>Correct '<i>dot-and-cross</i>' arrangement of B covalently '<i>dot-and-cross</i>' bonded to three F atoms, including full octet on F atoms  <b>AND</b>            Correct '<i>dot-and-cross</i>' arrangement of N covalently '<i>dot-and-cross</i>' bonded to three H atoms ✓            Dative covalent shown between N and B atoms ✓</p>	2	<p>Must be '<i>dot-and-cross</i>', but <b>ALLOW</b> other symbols for electrons of third and fourth atoms eg <math>\Delta</math>, +, o, etc</p> <p>Circles for outer shells are not needed  <b>IGNORE</b> inner shells  <b>IGNORE</b> use of charges</p> <p>Non-bonding electrons of F do not need to be seen as pairs</p> <p><b>IGNORE</b> dative-covalent arrows from N to B, but  <b>DO NOT ALLOW</b> arrow from B to N</p> <p><b>DO NOT ALLOW</b> two separate molecules for first mark</p> <p><b>DO NOT ALLOW</b> dative covalent bond mark if electron pair matches the B electrons ie to be correct the dative pair must be the same symbol as non-bonding electrons on F atoms if only two symbols are used</p> <p><b>DO NOT ALLOW</b> dative covalent bond mark if F atoms have no non-bonding electrons <b>UNLESS</b> B has different electron symbol to N or H atoms</p>
		(iii)	<p><math>\text{BF}_3 = 120(^{\circ})</math> ✓  <math>\text{H}_3\text{NBF}_3 = 109.5(^{\circ})</math> ✓</p>	2	<p><b>ALLOW</b> 109–110(<math>^{\circ}</math>) for <math>\text{H}_3\text{NBF}_3</math></p>

Question			Answer	Marks	Guidance
3	(e)	(iv)	(N in) $\text{NH}_3$ has three bonding pairs and one lone pair of electrons ✓  (N in) $\text{H}_3\text{NBF}_3$ has <b>four</b> bonding pairs (and no lone pairs) of electrons <b>OR</b> Lone pair on N now becomes bonding pair ✓  Lone pair of electrons repels <b>more</b> than bonding pairs ✓	3	<b>ALLOW</b> 'bonds' for 'bonding pairs'  <b>IGNORE</b> 'electrons repel' <b>DO NOT ALLOW</b> 'atoms repel'
			<b>Total</b>	<b>20</b>	

Question	Answer	Marks	Guidance
4 (a)	<p>Reactivity increases (down the group) ✓</p> <p><i>Increasing size mark</i> Atomic radius increases <b>OR</b> There are more shells ✓</p> <p><i>Increased shielding mark</i> There is <b>more</b> shielding ✓</p> <p><i>Nuclear attraction (to electron) mark</i> Nuclear attraction (to electron) decreases <b>OR</b> (outermost) electrons experience less attraction (to nucleus) <b>OR</b> Increased nuclear charge is outweighed by increased shielding/distance ✓</p> <p><i>Ease of electron loss mark</i> Easier to remove (outer) electron(s) <b>OR</b> Ionisation energy decreases ✓</p> <p><b>Quality of written communication</b> <i>electron(s) OR ionisation OR ionization OR oxidise OR oxidize spelled correctly at least once for last marking point</i></p>	5	<p><b>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</b></p> <p>'Down the group' is not required <b>ORA</b> throughout</p> <p><b>ALLOW</b> alternative phrases for 'reactivity increases'</p> <p><b>ALLOW</b> 'there are more energy levels' <b>ALLOW</b> 'electrons are in higher energy levels' <b>ALLOW</b> 'electrons are further from the nucleus' <b>IGNORE</b> there are more orbitals <b>OR</b> more sub-shells <b>ALLOW</b> 'different shell' <b>OR</b> 'new shell'</p> <p>There must be clear comparison ie 'more shielding' <b>OR</b> 'increased shielding' <b>ALLOW</b> there is <b>more</b> electron repulsion from inner shells <b>DO NOT ALLOW</b> responses which have no comparative eg 'there is shielding'</p> <p><b>ALLOW</b> 'there is less nuclear pull' <b>OR</b> 'electrons less tightly held' <b>IGNORE</b> there is less effective nuclear charge <b>IGNORE</b> 'nuclear charge' for 'nuclear attraction'</p> <p>If question is answered in terms of only Group 7, then <b>ONLY</b> marks 2, 3 and 4 can be awarded</p> <p><b>ALLOW</b> easier to oxidise</p>

Question			Answer	Marks	Guidance
4	(b)	(i)	$\text{AgNO}_3(\text{aq})$ <b>OR</b> silver nitrate <b>OR</b> $\text{AgNO}_3$ ✓	1	<b>ALLOW</b> $\text{Ag}^+(\text{aq})$
		(ii)	Yellow <b>AND</b> precipitate ✓	1	<b>ALLOW</b> shades of yellow but not creamy yellow <b>ALLOW</b> ppt or solid for precipitate
		(iii)	$\text{Ag}^+(\text{aq}) + \text{I}^-(\text{aq}) \rightarrow \text{AgI}(\text{s})$ ✓	1	<b>ALLOW</b> correct multiples
		(iv)	<b>concentrated</b> (aqueous) $\text{NH}_3$ ✓	1	
			<b>Total</b>	<b>9</b>	

Question			Answer	Marks	Guidance
5	(a)	(i)	<p><i>Nuclear charge mark</i> (Across the period) number of protons increases <b>OR</b> greater nuclear charge ✓</p> <p><b>Quality of written communication – nuclear OR proton(s) OR nucleus spelled correctly ONCE for the first marking point</b></p> <p><i>Distance / shielding mark</i> (Outermost) electrons are in the same shell <b>OR</b> (Outermost) electrons experience the same shielding <b>OR</b> Atomic radius decreases ✓</p> <p><i>Nuclear attraction (to electron) mark</i> Greater nuclear attraction (on outermost electrons) <b>OR</b> (outer) electrons are attracted more strongly (to the nucleus) ✓</p>	3	<p><b>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</b></p> <p>Comparison should be used for each mark</p> <p><b>IGNORE</b> atomic number increases, but <b>ALLOW</b> proton number increases <b>IGNORE</b> nucleus gets bigger <b>IGNORE</b> 'effective nuclear charge increases' <b>DO NOT ALLOW</b> 'charge' increases without reference to nuclear</p> <p><b>ALLOW</b> shielding is similar BUT <b>IGNORE</b> 'there is shielding' <b>DO NOT ALLOW</b> sub-shells <b>OR</b> orbitals</p> <p><b>ALLOW</b> greater nuclear pull for greater nuclear attraction <b>DO NOT ALLOW</b> use of greater nuclear charge for greater nuclear attraction for third mark</p>
		(ii)	(Diamond and graphite form) <b>gaseous atoms</b> (of carbon when they are ionised) ✓	1	<b>ALLOW</b> the <b>atoms</b> are in the <b>gaseous</b> state



Question		Answer			Marks	Guidance
	(b)		<b>Lithium</b>	<b>Carbon (diamond)</b>	<b>Fluorine</b>	<p><b>6</b></p> <p><b>ALLOW</b> shared pair of electrons for covalent (bond)</p> <p><b>ALLOW</b> vdw for van der Waals'</p> <p><b>ALLOW</b> temporary–induced or instantaneous–induced for van der Waals'</p> <p><b>ALLOW</b> Positive ions for Li<sup>+</sup> ions</p> <p><b>IGNORE</b> 'Lithium ions' but <b>ALLOW</b> 'Positive lithium ions'</p> <p><b>DO NOT ALLOW</b> Li<sup>2+</sup></p> <p><b>IGNORE</b> C and <b>IGNORE</b> F<sub>2</sub></p> <p><b>IGNORE</b> diagrams but <b>ALLOW</b> names of particles if seen as a label on a diagram</p> <p><b>DO NOT ALLOW</b> implication that covalent bonds are broken in fluorine for the <i>particles</i> mark of fluorine as this implies the particles are atoms</p>
		<b>Structure</b>	Giant	Giant ✓	Simple	
		<b>Force or bond overcome on melting</b>	Metallic bond	Covalent (bond) ✓	van der Waals' (forces) <b>OR</b> induced dipoles ✓	
		<b>Particles between which the force or bond is acting</b>	Li <sup>+</sup> ions and (delocalised) electrons ✓	Atoms ✓	Molecules ✓	
				<b>Total</b>	<b>10</b>	

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