Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			C ✓	1 (AO 2.1)	**<u>Examiner's Comments</u>** The nature of bonding continues to be a source of misunderstanding for most candidates, and option A was a frequent choice.
			Total	**1**	
2	a		**Any two from:** Each (carbon) atom forms 4 bonds ✓ All the (outer shell) electrons are used in bonding ✓ No electrons are able to move to conduct electricity ✓	2 (2 x AO 1.1)	**ALLOW** has no delocalised electrons / no sea of electrons **IGNORE** free electrons / ions **ALLOW** electrons cannot move (through the structure) **IGNORE** electrons cannot carry the charge **<u>Examiner's Comments</u>** The bonding in carbon was described by the most competent candidates, who also discussed the absence of delocalised electrons that could move. Many discussed the structure of graphite or the strength of the covalent bond in diamond. A significant number omitted the question. **Bonding** The bonding in carbon is giant covalent such that each carbon is bonded to 4 others. This means that all of the electrons are used in bonding so there are none available to move to conduct electricity.
	b	i	(Form of carbon) X ✓ An electrode needs to conduct electricity ✓	2 (2 x AO 3.2a)	**IGNORE** other properties **<u>Examiner's Comments</u>** The need for an electrode to conduct electricity was well known and many candidates chose X. Those that chose

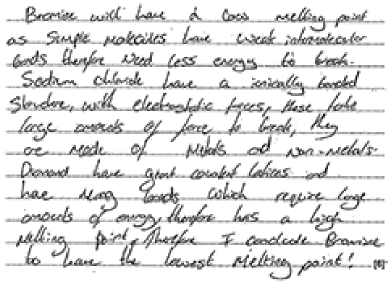
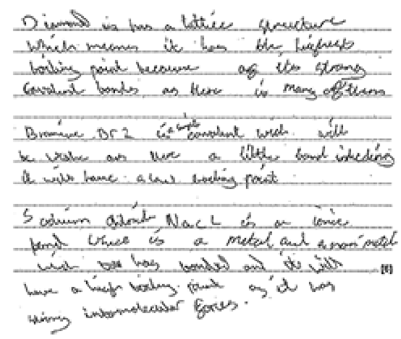
					Y or Z gave the reason as not conducting electricity.
		ii	Electrodes need to remain liquid, and not freeze at low temperatures ☐ Electrodes need to remain liquid, and not melt at high temperatures ☐ Electrodes need to remain solid, and not freeze at low temperatures ☐ Electrodes need to remain solid, and not melt at high temperatures ☑ ✓	1 (AO 2.2)	**<u>Examiner's Comments</u>** The high melting point of electrodes was quite well known. All responses were seen.
			Total	**5**	
3		i	The lower the melting point, the further the sample can stretch (before breaking) / **ORA** ✓	1 (AO 3.1a)	**ALLOW** the lower the melting point the higher the distance (stretched before breaking) **<u>Examiner's Comments</u>** The relationship was described by many candidates. Some described them as being harder or easier to stretch or discussed boiling point.
		ii	C_2H_2O ✓	1 (AO 2.2)	**ALLOW** $C_2H_2O_1$ **ALLOW** any order of symbols **DO NOT ALLOW** C^2H^2O / C2H2O **<u>Examiner's Comments</u>** Empirical formula was understood by the same candidates. Common incorrect responses included CHO, C_5H_5O and $C_{10}H_{10}O_5$. A large number omitted the question. **Misconception** Many candidates thought the empirical formula was either the molecular formula or the atoms in the molecule (e.g. CHO) rather than it being the simplest whole number ratio of the atoms in a molecule.
			Total	**2**	

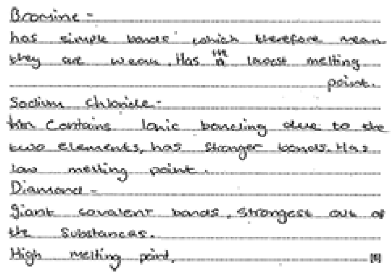
4			Seven ✓	1 (AO 2.2)	**<u>Examiner's Comments</u>** Many candidates calculated the order of magnitude correctly. The most popular incorrect response was four.
			Total	**1**	
5	a		**First check the answer on the answer line** **If answer = 9000 (kg) award 3 marks** Correctly takes 50 and 30 from chart ✓ (50–30) = 20 (%) ✓ $\frac{45,000 \times 20}{100} = 9000$ (kg) ✓	3 (3 x AO 2.2)	**ALLOW ECF** from incorrect percentage **<u>Examiner's Comments</u>** Many candidates appreciated that 20% of the plastic waste was not able to be recycled. Some found calculating this percentage challenging, often dividing 45,000 by 20. A small number thought 30% was not able to be recycled and were able to score error carried forward marks by showing their working. **OCR support** Exambuilder can be used to isolate mathematical skills questions from our bank of exam papers to specifically assess skills like order of magnitude. These could be used in conjunction with our Mathematical skills handbook and Mathematical skills check in resources.
	b	i	Idea that a covalent bond is a shared **pair** of electrons (between atoms) ✓	1 (AO 1.1)	**<u>Examiner's Comments</u>** Candidates found this very challenging with few appreciating the sharing of a pair of electrons. Many thought electrons would be swapped or that metallic bonds were formed. A significant number omitted the question.
		ii	**Any two from:** Plastic bag polymer stretches or	2 (2 x AO 2.1)	**ORA** **ALLOW** bottle has a (more) fixed

			plastic bottle polymer is rigid / plastic bottle polymer is hard(er than plastic bag) polymer ✓ Polymer used for plastic bottle will have high(er) melting point (than plastic bag polymer) ✓ Plastic bottle polymer is strong(er than plastic bag polymer) ✓ Plastic bag polymer has weak intermolecular forces ✓ Plastic bottle polymer has strong cross-links ✓		shape / bag doesn't have a fixed shape **ALLOW** Plastic bag polymer is flexible / plastic bottle polymer is not flexible/is hard to squeeze **IGNORE** elastic / brittle **ALLOW** hard to break for strong **IGNORE** thicker and thinner **Examiner's Comments** Highly successful candidates usually discussed strength or flexibility of the polymers and rarely both. The many incorrect responses included: thickness and thinness, strong and weak bonds, transparent and not, more and less polymers used, lighter and heavier, moving and not moving freely, larger and smaller polymers, hard to make and easy to make and recycled and not recycled.
	c		**Any two from:** Rulers need to be rigid ✓ (stretch makes) scale/lines/graduations stretch apart ✓ measurements are incorrect / too small ✓	2 (2 x AO 3.1b)	**IGNORE** rulers should not be stretchy **ALLOW** inaccurate / different / reading is too small **ALLOW** measurements would stretch **Examiner's Comments** Many candidates understood that the measurements on the stretched ruler would be inaccurate and the most competent added that the stretching moved the graduations apart. Incorrect responses included the rulers going back to their original length after stretching, their strength being reduced, becoming easy to break and being flimsy.
			Total	**8**	
6		i	1.2 (nm) ✓	1 (AO 1.2)	**Examiner's Comments** The highest attaining candidates understood the unit of nanometres. 1 200 000 000 was a very popular response.

		ii	The nanotubes are only bonded by strong (covalent) bonds (which is why the nanotube is strong) ✓ Graphite has weak forces of attraction between the layers/forces between the layers are easily broken (therefore, it is not as strong) ✓	2 (AO 2 x 1.1)	**ALLOW all** bonds are strong /**all** the carbon atoms are bonded together **DO NOT ALLOW** stronger intermolecular forces in graphene **ALLOW** the layers in graphite can slide **IGNORE** intermolecular in graphite **Examiner's Comments** The highest attaining candidates appreciated that all of the atoms in the nanotube are bonded by strong covalent bonds and that there are weak forces between the layers in graphite. Comparing the bonds as weak in graphite and strong in graphene or rewriting the question stem were popular responses. **Bonding** Covalent bonds are strong. What makes graphene stronger than graphite is that all of the atoms are bonded by these strong bonds in graphene in a network, whereas the strong covalent bonds are only within the layers of graphite and the layers are held together by weak forces which are easily broken. The forces between the layers in graphite are not intermolecular forces.
		iii	**First check the answer on answer line** **If answer = 5 award 2 marks** $1.2 \times 10^{-9} \div 2.4 \times 10^{-10}$ ✓ = 5 ✓	2 (AO 2 x 2.1)	**Examiner's Comments** The highest attaining candidates divided the largest diameter by the smallest and gave an answer of 5. The most popular response was 0.2 from an inverted division where the smallest diameter was divided by the largest. Standard form confused many candidates.
			Total	**5**	
7	a		**Level 3 (5–6 marks)** Applies detailed knowledge and understanding to describe the types of bonding and accurately links this to compare the melting points. **AND**	6 (AO 4 x 2.1) (AO 2 x 3.2b)	**AO2.1 Apply knowledge and understanding of scientific ideas** • Ionic bonds / electrostatic forces in NaC*l* are very strong

			Predicts that bromine has the lowest melting point *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Applies some knowledge and understanding to describe the types of bonding. Basic comparison made. **AND** Predicts that bromine has the lowest melting point *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Attempts to apply knowledge and understanding to describe the types of bonding. Limited or no comparison made. **OR** Predicts that bromine has the lowest melting point. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 mark** *No response or no response worthy of credit.*		• Ionic bonds / electrostatic forces in Na*Cl* require a lot of energy to break • Covalent bonds in diamond are very strong • Diamond has many strong covalent bonds • Covalent bonds in diamond require a lot of energy to break • Intermolecular forces in Br_2 are weak • Intermolecular forces in Br_2 require less energy to break **AO3.2b Analyse information to make judgements and draw conclusions** • Bromine has the lowest melting point • Sodium chloride has a higher melting point than bromine • Diamond has a higher melting point than bromine **<u>Examiner's Comments</u>** Level 1 needed a comment about bromine being the lowest melting point or a discussion of the forces in some of the substances. Level 2 needed choosing bromine as the lowest and a discussion of the bonding in more detail. Level 3 needed discussion of intermolecular forces and of energy needed to break bonds/forces. Sodium chloride was often chosen as having covalent bonding or the lowest melting point. Many candidates discussed bonding between a metal and a non-metal or rewrote the information from the table. Exemplar 1

					 Bromine will have a low melting point as simple molecules have weak intermolecular bonds therefore need less energy to break. Sodium chloride have a ionically bonded structure, with electrostatic forces, these take large amounts of force to break, they are made of metals and non-metals. Diamond have giant covalent lattices and have many bonds which require large amounts of energy therefore has a high melting point. Therefore I conclude Bromine to have the lowest melting point! [6] Bromine was chosen as having the lowest melting point with weak intermolecular forces as the reason, linked to less energy to break them. Sodium chloride has electrostatic forces which require large force to break (force was condoned in this context since energy is used when referring to bonds in diamond). Diamond has many covalent bonds which require large amounts of energy (to break), hence high melting point. A response does not need to be perfect in order to score 6 marks. This response has the lowest melting point substance chosen, the bonding discussed, weak intermolecular forces in bromine and the energy required to overcome the bonding for all three substances. This is level 3, 6 marks. Exemplar 2  Diamond is has a lattice structure which means it has the highest boiling point because of the strong covalent bonds as there is many of them. Bromine Br2 is simple covalent which will be weaker as there a little bond [illegible] it will have a low boiling point. Sodium chloride NaCl is a ionic bond which is a metal and a non-metal which has bonded and it will have a high boiling point as it has strong intermolecular forces. [6] Sodium chloride and diamond have high melting point and bromine low, hence bromine has the lowest melting point. Diamond has many strong bonds. Strong intermolecular forces in sodium chloride was incorrect. This is Level 1, 2 marks.

					Exemplar 3  Bromine - has simple bonds which therefore mean they are weak. Has the lowest melting point. Sodium chloride - It contains ionic bonding due to the two elements, has stronger bonds. Has low melting point. Diamond - Giant covalent bonds, strongest out of the substances. High melting point. [6] This response has bromine chosen as having the lowest melting point. It also includes sodium chloride and diamond having strong bonds. Weak intermolecular forces are not discussed, nor is the energy required to break the bonds in the three substances. The response suggests that bromine has weak bonds; however the bonds in bromine are strong – it is the forces between the molecules that are weak. This is Level 2, 3 marks.
	b	i	A metal alloy has different sized atoms **ORA** ✓ The atoms/ions/particles of the same size can slide over each other more easily **ORA** ✓	2 (AO 2 x 1.1)	**ALLOW** different sized particles/ions **IGNORE** has large/giant particles **DO NOT ALLOW** molecules for M1 only **DO NOT ALLOW** different sized elements for M1 only **ALLOW** different sized atoms/ions/particles makes it harder for layers/atoms/ions/particles to slide **<u>Examiner's Comments</u>** Higher scoring candidates appreciated that the alloy contains different sized atoms. Two elements, so stronger bonds was a common response, as was rewriting the question. **Metals and alloys** In pure metals the rows of atoms are able to slide. Alloys are stronger because the added atoms are a different size to the atoms of the pure metal and so they disrupt the regular

					pattern and the layers are no longer able to slide as well.
		ii	Alloy 2 ✓ **Any two from:** It is non-toxic ✓ It has a low/medium density ✓ It is strong ✓	3 (AO 3 x 3.2a)	**ALLOW** reverse arguments for why alloys 1 and 3 are not selected **ALLOW** not too dense **ALLOW** it has high tensile strength / doesn't break easily / can support more weight
			Total	**11**	
8			**B**	1 (AO 2.1)	**Examiner's Comments** A was the most popular incorrect response.
			Total	**1**	
9		i	B ✓	1 (AO 1.1)	
		ii	Any value between -218 and -184 (°C) ✓	1 (AO 2.1)	**Examiner's Comments** Most candidates gave a negative temperature; -180, -219 and -220 were all popular incorrect responses.
		iii	A liquid becoming a solid is called **freezing**. ✓ In a solid, the particles move **less** ✓ than in a liquid. In a solid, the arrangement of particles is **less** ✓ random than in a liquid.	3 (AO 3 x 1.1)	**Examiner's Comments** Higher scoring candidates chose freezing, less and less. Condensing was seen for the change of state and the particles being more random was also popular.
			Total	**5**	
10			**B**	1 (AO 1.1)	**Examiner's Comments** The most popular incorrect response was D where the two properties of nanomaterials were reversed.
			Total	**1**	
11		i	Less than 1 nm ☐ Between 1 and 100 nm ☑ ✓	1(AO1.1)	**Examiner's Comments** More successful candidates gained the mark. Many candidates chose less than 1 nm.

			Between 100 and 1000 nm ☐ Greater than 1000 nm ☐		
		ii	**Advantage** Idea that nanoparticulate materials have different properties to the same substance in bulk ✓ **Disadvantage** **Any one from**: Idea that nanoparticles haven't been tested for long-term effects / idea that the risks of nanoparticles aren't yet fully understood Nanoparticles may be breathed in or absorbed by the skin or pass into cells Idea that nanoparticles may take a long time to break down once released into the environment ✓	2(2 × AO1.1)	**ALLOW** specific properties of nanoparticles e.g. particles can be white in bulk but transparent when nanoparticulate or nanoparticles have a very large surface area to volume ratio or different properties to the bulk material or delivery of drugs / removes smell from clothing / catalysts / antimicrobial / strength to materials / sunscreen **ALLOW** idea that not much research into the **effects** of them **<u>Examiner's Comments</u>** The most successful candidates identified either an advantage or a disadvantage of nanomaterials. Incorrect responses for advantages included small, strong, a medicine, can fit through the skin; and for disadvantages small, can't be seen, can be lost easily, toxic, hard to work with and dangerous.
			Total	**3**	
12	a	i	Ionic compounds have high melting and/or boiling points ✓ Ionic compounds can conduct (electricity) when molten or dissolved, but not as a solid ✓	2(2 × AO3.1b)	**ALLOW** only conducts (electricity) when liquid or dissolved **ALLOW** soluble <u>in water</u> **<u>Examiner's Comments</u>** High boiling point/melting point was well known. Many discussed electrical conductivity with more successful candidates including solid, molten and dissolved in their answer.
		ii	B ✓ (B) has a low melting point / a low boiling point ✓ (B) cannot conduct electricity ✓	3(3 × AO3.2b)	**IGNORE** insoluble in water **ALLOW** D and cannot conduct electricity **<u>Examiner's Comments</u>** The more successful candidates knew the properties of the simple covalent

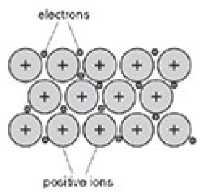
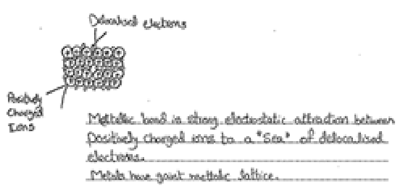
	b	i			compound B. Most candidates chose substance C.
		iii	Gas ✓	1(AO2.1)	**Examiner's Comments** The most successful candidates determined the state of substance B, solid was the most popular incorrect response.
	b	i	Positive (metal) ions ✓ Idea of the ions being surrounded by a sea of electrons ✓ Idea that there are strong forces of attraction between ions and electrons ✓	3(AO1.1)	**Any reference to ionic or covalent bonding or IMF scores 0** **ALLOW** a labelled diagram  In a diagram there must be at least one electron in the body of the ions Diagram must show **close packed** metal ions, in a regular arrangement **ALLOW** - / e / e- / dots for electrons labelled If e or e- are used they do not need labelling but just a dot or – unlabelled does not score **ALLOW** circles with + or circles labelled positive ions **IGNORE** free electrons If M1 **and** M2 scored allow strong (metallic) bond for M3 **Examiner's Comments** The most successful responses gave a labelled diagram and described the bonding. Diagrams were often missing or unlabelled and often diamond. Many discussed ionic or covalent bonding. A large number omitted the question. Exemplar 1 

					Diagram has close packed regular positive ions and labelled, ions interspersed with delocalised electrons and labelled; text has strong attraction between positive ions and delocalised electrons. This response gained all 3 marks.
		ii	Idea that layers or rows or sheets (of particles) slide over each other ✓	1(AO1.1)	**IGNORE** layers can bend **IGNORE** IMF **Examiner's Comments** The most successful responses discussed layers. Many discussed weak bonding, delocalised electrons or forces between atoms and a large number omitted the question
		iii	Has electrons ✓ (Electrons) that can move (through the metal) ✓ **OR** Delocalised electrons scores ✓ ✓	2(2 × AO1.1)	**DO NOT ALLOW** free ions – scores 0 **IGNORE** free (electrons) for idea of movement **IGNORE** carry charge **Examiner's Comments** More successful responses discussed electrons and the most successful described the electrons as moving. Popular responses included bonding, close packing of atoms allowing conduction and moving ions.
		iv	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 3:2 award 2 marks** (Lead:tin ratio in diagram =) 12:8 ✓ Divide by 4 to give smallest ratio = 3:2 ✓	2(2 × AO2.1)	**ALLOW** tin:lead in diagram = 8:12 **Examiner's Comments** This was answered well, a small number of candidates gave 12:8, simplified to 6:4 or reversed the ratio.
		v	As the silver content increases, the melting point decreases **ORA** ✓	1 (AO3.1a)	both variables must be comparative **Examiner's Comments** More successful candidates derived the link between silver content and melting point. Popular incorrect responses included high melting point, low melting point and the melting point increasing as silver content increases.

			Total	**15**	
13			C ✓	1(AO1.1)	**<u>Examiner's Comments</u>** More successful responses chose atoms and subatomic particles, response A was very popular and a smaller number chose response B.
			Total	**1**	
14			C ✓	1(AO2.1)	**<u>Examiner's Comments</u>** Most confident candidates placed 25˚C between the melting point and boiling point of mercury, A was the most popular incorrect response.
			Total	**1**	
15			B ✓	1(AO1.1)	**<u>Examiner's Comments</u>** A and D were the most popular responses.
			Total	**1**	