1(a). Look at the table of data.

| Material | Strength (arbitrary units) | Resistance to corrosion | Density ($g/cm^3$) | Electrical conductivity | Cost (£ per tonne) |
|---|---|---|---|---|---|
| Aluminium | 222 | Good | 2.8 | Very good | 750 |
| Titanium alloy | 850 | Good | 4.4 | Good | 8000 |
| Carbon-fibre-reinforced-polymer | 2457 | Good | 1.5 | Very good | 10000 |
| Steel | 254 | Poor | 7.8 | Good | 65 |
| PVC | 69 | Good | 1.3 | Poor | 490 |

* A chair manufacturer is making a garden chair.

The manufacturer needs to decide which material to use to make the chair.

Some of the materials are metals and some are polymers.

Describe and compare the bonding of the materials in the table and suggest which of them would be best for making the chair, giving reasons for your answer.

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**[6]**

(b). Power companies use aluminium wire for over-head power cables.

What are the **two** most important properties of aluminium for this use?

Use information from the table.

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**[2]**

2. Element **Z** has the electronic structure 2.8.8.1.

Explain how you can tell that the element is potassium.

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**[1]**

3. Rubidium is found in Group 1 of the Periodic Table. Bromine is found in Group 7. They react together to form an ionic compound.

Which row shows the electron change that occurs for rubidium and the correct formula of a rubidium ion?

| | Electron change | Formula of ion |
|---|---|---|
| **A** | Electron gained | $Rb^+$ |
| **B** | Electron gained | $Rb^-$ |
| **C** | Electron lost | $Rb^+$ |
| **D** | Electron lost | $Rb^-$ |

Your answer ☐

**[1]**

4. Magnesium reacts rapidly with hydrochloric acid.

Barium reacts **more** rapidly with hydrochloric acid.

Explain why. Use ideas about loss of electrons.

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**[2]**

5. Sodium, Na, reacts with oxygen, $O_2$, to make sodium oxide.

Sodium oxide contains the ions, $Na^+$ and $O^{2?}$.

The electronic structure for sodium is 2.8.1.

The electronic structure for oxygen is 2.6.

Use the charges of the ions in sodium oxide to work out the formula of sodium oxide.

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**[1]**

6. Boron, B, is in Group 3 of the Periodic Table.

Write down the name of one **other** element in Group 3.

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**[1]**

7. Describe the metallic bonding in metals and use this to explain why most metals have a high melting point.

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---[3]

8. Sodium, Na, reacts with oxygen, $O_2$, to make sodium oxide.

Sodium oxide contains the ions, $Na^+$ and $O^{2?}$.

The electronic structure for sodium is 2.8.1.

The electronic structure for oxygen is 2.6.

Use 'dot and cross' models to describe the bonding in both sodium oxide and in a molecule of oxygen, $O_2$.

You only need to draw the outer shell electrons.

*The quality of written communication will be assessed in your answer to this question*.

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---[6]

9. Zinc carbonate has the formula $ZnCO_3$.

How many **different elements** are bonded together in zinc carbonate?

---------- **[1]**

10. Calcium, Ca, reacts with oxygen, $O_2$, to make calcium oxide, CaO.

calcium + oxygen ? calcium oxide

Use the formulas given to write the **balanced symbol** equation for the reaction between calciumand oxygen.

Explain why $O_2$ is a molecule and CaO is a compound.

*The quality of written communication will be assessed in your answer to this question.*

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---[6]

11(a) This question is about structure and bonding.

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Calcium chloride contains calcium ions, $Ca^{2+}$, and chloride ions, $Cl^-$.

Write down the **formula** for calcium chloride.

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[1]

(b). Sodium oxide has a high melting point and does not conduct electricity as a solid.

Use ideas about structure and bonding to explain why.

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[2]

(c). Sodium oxide, $Na_2O$, is an ionic compound.

Sodium has the electronic structure 2.8.1.

Oxygen has the electronic structure 2.6.

Use ‘dot and cross’ diagrams to draw the electronic structures of the two ions in $Na_2O$.

Include the charges on the ions.

**[2]**

12. Look at the table. It shows part of an early version of the Periodic Table of the Elements.

The numbers are the relative atomic masses of the elements.

| | | | | | | |
|---|---|---|---|---|---|---|
| H<br>1 | Li<br>7 | Be<br>9 | B<br>11 | C<br>12 | N<br>14 | O<br>16 |
| F<br>19 | Na<br>23 | Mg<br>24 | A*l*<br>27 | Si<br>28 | P<br>31 | S<br>32 |
| *Cl*<br>35.5 | K<br>39 | | | | | |

Three chemists helped with the development of the Periodic Table.

One of the chemists was Mendeleev.

He used the work of two other chemists.

They were:

- Dobereiner, who noticed triads
- Newlands, who developed the law of octaves.

Write about the work of **Dobereiner** and **Newlands** which contributed to the development of the Periodic Table.

*The quality of written communication will be assessed in your answer to this question.*

[6]

13. Look at the table. It shows part of an early version of the Periodic Table of the Elements.

The numbers are the relative atomic masses of the elements.

| | | | | | | |
|---|---|---|---|---|---|---|
| H<br>1 | Li<br>7 | Be<br>9 | B<br>11 | C<br>12 | N<br>14 | O<br>16 |
| F<br>19 | Na<br>23 | Mg<br>24 | Al<br>27 | Si<br>28 | P<br>31 | S<br>32 |
| Cl<br>35.5 | K<br>39 | | | | | |

Three chemists helped with the development of the Periodic Table.

One was Dobereiner, who noticed triads such as Li, Na and K.

The other two chemists were:

- Newlands
- Mendeleev.

Write about the evidence that **Newlands** and **Mendeleev** used to develop the Periodic Table.

*The quality of written communication will be assessed in your answer to this question.*

[6]

14. Metals such as iron are good conductors of electricity and have a high melting point.

Use a labelled diagram to describe metallic bonding.

[2]

15. Chlorine has the electronic structure 2.8.7.
Chlorine reacts with non-metals and metals.

Chlorine, $Cl_2$, reacts with hydrogen, $H_2$, to make hydrogen chloride, HCl.

(i) Write the **balanced symbol** equation for this reaction.

[2]

(ii) Hydrogen chloride is a **covalent** molecule.

Use the 'dot and cross' model to show the covalent bonding in hydrogen chloride.

Hydrogen has the electronic structure 1.

You only need to show the outer shell electrons.

[1]

16(a) An element has an **atomic number** of 47.

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Use the Periodic Table to write the **name** of this element.

---------- [1]

(b). Is this element a **transition element**?

Explain your answer. Use information from the Periodic Table.

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---------- [1]

17(a) Chlorine has the electronic structure 2.8.7.

. Chlorine reacts with non-metals and metals.

Chlorine has the electronic structure 2.8.7 and sodium the electronic structure 2.8.1.

Chlorine reacts with sodium to make sodium chloride, NaC*l*.

Sodium chloride is an **ionic** compound.

Use the 'dot and cross' model to show the ionic bonding in sodium chloride.

Include the charges on the ions.

You only need to show the outer shell electrons.

**[2]**

(b). Sodium chloride has a high melting point.

Explain why.

Use ideas about structure and bonding.

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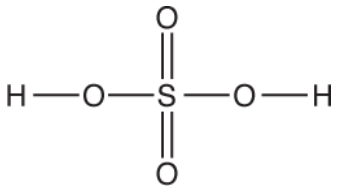
---**[2]**

18. Look at the displayed formula for sulfuric acid.



The atoms in a sulfuric acid molecule are held together by covalent bonds.

Explain how a covalent bond is made.

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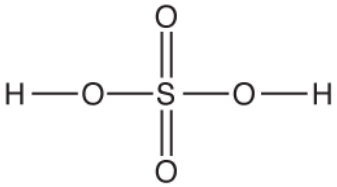
[1]

19. Look at the displayed formula for sulfuric acid.



The atoms in a sulfuric acid molecule are held together by covalent bonds.

What is the name of the **other** type of bond that holds atoms together?

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[1]

20. Phosphorus bonds with hydrogen to form the toxic gas phosphine, $PH_3$.

Draw a 'dot and cross' diagram to show the **covalent** bonding in $PH_3$.

**[2]**

21.

Look at the displayed formula of carbon dioxide.

O = C = O

The bonds between the carbon atom and the oxygen atoms are **covalent** bonds.

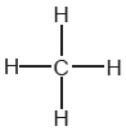
Draw a ‘dot and cross’ diagram to show the bonding in carbon dioxide.

Only draw the outer shell electrons.

**[2]**

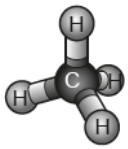
22. Methane, $CH_4$, is the simplest alkane.

The diagrams below are three ways to show the structure of methane.



A


B



C

Write about the **advantages** and **disadvantages** of each of these diagrams.

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[4]

23.

Some elements bond to form compounds by **ionic bonding**.

Describe what is meant by ionic bonding.

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[2]

24. * Look at the information about three elements **X, Y** and **Z** in the Periodic Table.

| Element | X | Y | Z |
|---|---|---|---|
| Atomic number | Less than 11 | 11 | More than 11 |
| Melting point (°C) | 181 | 98 | 64 |
| Number of electrons in outer shell | 1 | 1 | 1 |
| Density (g / cm3) | 0.53 | 0.97 | 0.89 |
| Reaction with water | Reacts quickly making hydrogen | Reacts vigorously making hydrogen | Reacts explosively making hydrogen |
| Action of heat on the carbonates of X, Y and Z | Breaks down and makes carbon dioxide | No reaction | No reaction |
| Formula of chloride | XC*l* | YC*l* | ZC*l* |
| Melting point of chloride (°C) | 614 | 801 | 773 |

Student A thinks that elements **X, Y and Z** are in the same Group of the Periodic Table.

Student B thinks they are in different Groups of the Periodic Table.

Analyse and explain the information in the table that supports **both** Student A's and Student B's conclusions.

Who do you think is correct?

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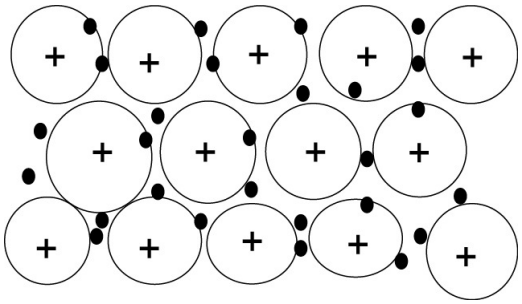
[6]

END OF QUESTION PAPER

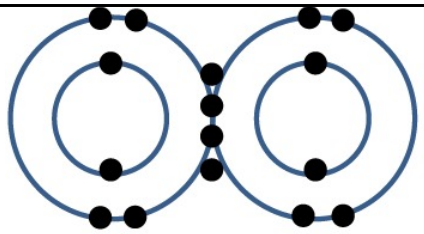
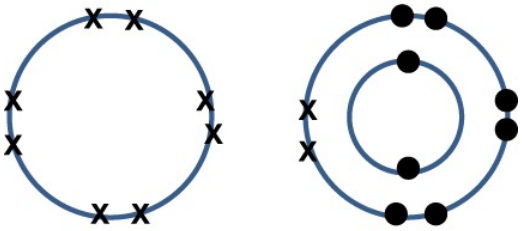
| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | a | | **Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*<br><br>**Level 3 (5–6 marks)**<br><br>**Describes the bonding of both materials**<br>**AND**<br>**Makes a comparison**<br>**AND**<br>**Makes a choice with a justified reason**<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br><br>**Describes the bonding of both materials**<br>**OR**<br>**Describes the structure of one material**<br>**AND**<br>**makes a choice with a justified reason**<br><br>*There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br><br>**Describes the bonding of one material**<br>**OR**<br>**makes a choice with a justified reason**<br><br>*The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.*<br><br>**0 marks** *No response or no response worthy of credit.* | 6 | **AO1.1: Knowledge of bonding in metals and polymers**<br><br>Bonding in polymers:<br><br>• Covalent bonds in molecule / Macromolecule.<br>• Weak intermolecular forces.<br>• Some have cross linkages.<br><br>Bonding in metals:<br><br>• Cationic lattice.<br>• Free/mobile pool of electrons.<br><br>Comparison<br><br>• Polymers are weaker because intermolecular forces are weaker than metallic bonds.<br>• Metals conduct electricity because of free electrons.<br><br>**AO3.2a: Analyse information in the table to make judgements**<br><br>• Not carbon-fibre-reinforced-polymer – too expensive.<br>• Aluminium – strong, corrosion resistant, low density so easy to carry but quite expensive.<br>• Steel – strong, cheap but higher density so heavy to carry, corrodes/rusts but can be painted to make look better and resist corrosion.<br>• PVC – corrosion resistant, low density means cost per chair is low, easy to carry, easy to shape, may not be strong enough.<br>• Titanium – strong, corrosion resistant, fairly low density but very expensive. |
| | b | | Conduction of electricity (1)<br>Low density/corrosion resistance (1) | 2 | |
| | | | **Total** | **8** | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 2 | | | (add up number of electrons) and this is the atomic number (and look up on periodic table) (1) | 1 | **ALLOW** has 19 electrons and on the Periodic Table, element number 19 is potassium<br><br>**ALLOW** element is in Group 1 and Period 4<br><br>**DO NOT ALLOW** it has 19 electrons on its own |
| | | | **Total** | 1 | |
| 3 | | | C | 1 | |
| | | | **Total** | 1 | |
| 4 | | | (in barium) outer shell electrons are further from the nucleus/(in barium) nuclear attraction for outer shell electrons is less (1)<br>so are lost more easily (1) | 2 | **ALLOW** ora for magnesium<br><br>**IGNORE** electrons are lost faster |
| | | | **Total** | 2 | |
| 5 | | | $Na_2O$ / $ONa_2$ (1) | 1 | **allow** $(Na^+)_2O^{2?}$<br>**allow** answer on right hand side of equation (the equation does not need to be balanced)<br><br>eg Na + $O_{2?}$ > $Na_2O$ (1)<br><br>**Examiner's Comments**<br><br>Very few candidates correctly gave the formula of sodium oxide. A significant number of answers gave the electron configuration. |
| | | | **Total** | 1 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | | | aluminium / gallium / indium / thallium / A*l* / Ga / In / T*l* (1) | 1 | symbols must be correct if given<br><br>Examiner's Comments<br><br>This question was about group 3 elements. Candidates were asked to name a group 3 element. This proved straight forward and the majority of candidates gave the answer aluminium with the usual variety of spellings. The more adventurous chose indium or gallium. |
| | | | Total | 1 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 7 | | | close (packed) positive ions / positive ions in a regular pattern (1)<br><br>delocalised electrons / mobile electrons / free electrons / sea of electrons (1)<br><br>strong attraction / bonds / forces (1)<br><br>all marks could be shown on a labelled diagram (minimum number of 6 positive ions) | 3 | **ignore** atoms **allow** metal ions / cations<br><br>**not** intermolecular forces / ionic bonds / covalent bonds<br>**ignore** electromagnetic bonds<br>**allow** lots of energy needed to break bonds / overcome attractions / forces<br><br>  <br><br>**allow** large circles with positive signs in for positive ions<br>**allow** e as electrons but small circles or negative charges need to be labelled as electrons<br><br>**Examiner's Comments**<br><br>Many candidates did not include a diagram, but those that did tended to score more marks. The most common error was to state that there are strong intermolecular bonds. |
| | | | **Total** | 3 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 8 | | | [Level 3]<br>Use the dot and cross model to explain the covalent bonding in an oxygen molecule<br>AND<br>draw the electronic structures of the sodium ion and the oxide ion<br>Quality of written communication does not impede communication of the science at this level<br><br>(5 – 6 marks)<br><br>[Level 2]<br>Use the dot and cross model to explain the covalent bonding in an oxygen molecule<br>OR<br>Uses the dot and cross model to draw the electronic structures of the sodium ion and the oxide ion<br>Quality of written communication partly impedes communication of the science at this level<br><br>(3 – 4 marks)<br><br>[Level 1]<br>States or shows that $O_2$ is bonded covalently<br>OR<br>$Na_2O$ by ionic bonding<br>Quality of written communication impedes communication of the science at this level<br><br>(1 – 2 marks)<br><br>[Level 0]<br>Insufficient or irrelevant science. Answer not worthy of credit.<br><br>(0 marks) | 6 | This question is targeted at grades up to A*.<br><br>Indicative scientific points at all levels 2 and 3 could include:<br><br>• Dot and cross diagram for oxygen<br>• Electronic structure of sodium ion (no need to have charge but if shown must be correct)<br>• Electronic structure of oxide ion (no need to have charge but if shown must be correct)<br>• Idea that positive sodium ion attracts a negative oxide ion<br><br>**allow** $Na^+$ or an empty shell for electronic structure of sodium ion<br>**ignore** inner shells if drawn<br><br>Indicative scientific points at level 1 could include:<br><br>• $O_2$ has covalent bonding<br>• $O_2$ has shared pairs of electrons<br>• $Na_2O$ has ionic bonding<br>• $Na_2O$ bonding involves electron transfer<br>• Na loses electron and O gains electrons<br><br>Use the L1, L2, L3 annotations in scoris. Do not use ticks.<br><br>See next page for dot and cross diagrams. |

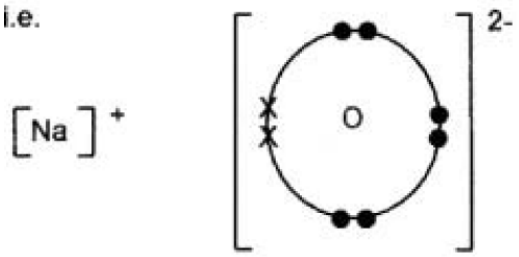
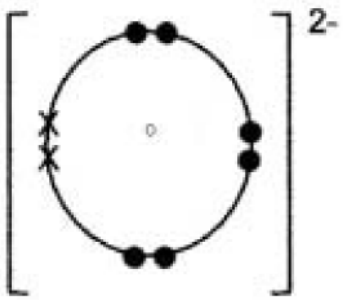
| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | | |  <br>$O_2$<br>  <br>sodium ion oxide ion<br><br>At level 2 and 3, if dot and cross diagram shows the same electron on the sodium ion and the oxide ion then answer is limited to lower mark within level<br>Credit word descriptions however for level 2 or 3 correct electron structures must be described eg $Na^{+}$ 2.8 $O^{2?}$ 2.8<br><br>Examiner's Comments<br><br>In many answers ideas about covalent and ionic bonding were mixed up. Some candidates did not realise that two models were required, and instead attempted to integrate the two. The few candidates that attempted the structure of $O_2$ scored well. |
| | | | Total | 6 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 9 | | | 3 (1) | 1 | ignore Zn, C and O / zinc, carbon and oxygen<br><br>Examiner's Comments<br><br>Many candidates correctly identified that there are three different elements in the formula $ZnCO_3$. Five, being the number of atoms in the formula, was a common misconception. Examiners also frequently saw the answer two, presumably from candidates who thought the different elements were Zn and CO. |
| | | | Total | 1 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 10 | | | [Level 3]<br>Clearly explains why $O_2$ is a molecule<br>AND<br>Clearly explains why CaO is a compound<br>AND<br>Constructs the correct balanced symbol equation<br>Quality of written communication does not impede communication of the science at this level<br>(5 – 6 marks)<br><br>[Level 2]<br>Clearly explains why $O_2$ is a molecule and clearly explains why CaO is a compound<br>OR Constructs the correct balanced symbol equation<br>Quality of written communication partly impedes communication of the science at this level<br>(3 – 4 marks)<br><br>[Level 1]<br>Clearly explains why $O_2$ is a molecule<br>OR<br>Clearly explains why CaO is a compound<br>OR<br>Constructs the unbalanced symbol equation<br>Quality of written communication impedes communication of the science at this level<br>(1 – 2 marks)<br><br>[Level 0]<br>Insufficient or irrelevant science. Answer not worthy of credit.<br>(0 marks) | 6 | This question is targeted at grades up to C.<br><br>Indicative scientific points at level 3 must include:<br><br>• $2Ca + O_2$ ? 2CaO or any other correct multiple<br><br>Relevant points at levels 1 and 2 could include<br><br>• CaO is a compound because it contains two elements chemically bonded<br>• CaO is a compound because (formula) has more than one element chemically bonded<br>• CaO is a compound because it contains calcium and oxygen chemically bonded<br>• CaO is a compound because (formula) has two different symbols<br><br>not CaO is a compound because it is a mixture of calcium and oxygen or two elements<br><br>• $O_2$ has two atoms bonded together<br>• $O_2$ has two oxygen atoms bonded together<br><br>not $O_2$ is a molecule because it is one (type of) atom<br><br>• Unbalanced symbol equation: eg Ca + $O_2$ ? CaO<br>ie symbols / formulae need to be correct<br><br>Use the L1, L2, L3 annotations in RM |

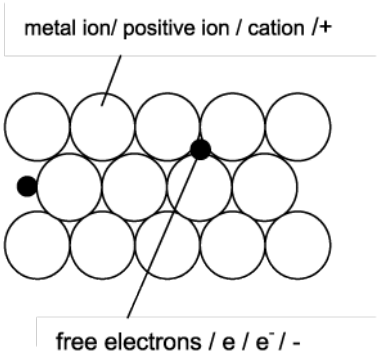
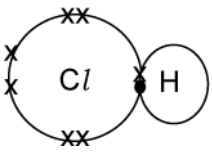
| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | | | Assessor; do not use ticks.<br><br>Examiner's Comments<br><br>This 6 mark question was targeted up to grade C. To gain credit at level 3 (5 – 6 marks) candidates needed to write the balanced symbol equation for the reaction between calcium and oxygen and to explain why $O_2$ is a molecule and CaO is a compound. Most candidates were unable to explain ideas about molecules and compounds and only gained credit at Level 1 for an unbalanced symbol equation. |
| | | | Total | 6 | |

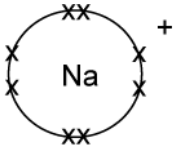
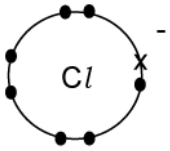
| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 11 | a | | $CaCl_2$ (1) | 1 | **not** CaCl2 / $CaCl^2$<br>**allow** as product of equation<br><br>**Examiner's Comments**<br><br>The best responses simply stated the formula of calcium chloride rather than trying to give an answer involving charged ions or an equation. |
| | b | | (high melting point because) there are **strong** attractions / forces / bonds between (positive and negative) ions (1)<br><br>(does not conduct electricity as a solid) as ions cannot move / ions are in fixed positions (1) | 2 | **not** references to intramolecular / intermolecular forces<br>**not** covalent<br>**ignore strong** attractions / bonds between particles but<br>**allow strong** attractions / bonds between charged particles<br>**allow** idea that it requires a lot of energy to break the ionic<br>bonds<br>**ignore** (charged) atoms<br>**allow strong** electrostatic attractions between ions<br><br>**ignore** reference to electrons<br><br>**Examiner's Comments**<br><br>In good answers candidates wrote accurately about ionic bonds. Marks were lost by only referring to strong bonds or intermolecular bonds and discussing the movement of electrons. |

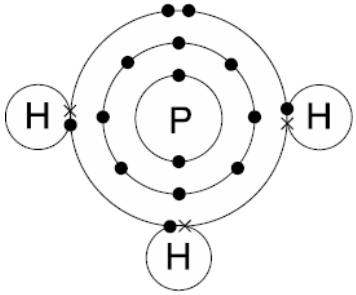
| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | c | | sodium ion drawn with either a full outer shell or an empty one and a charge of + 1<br>**or**<br>structure of sodium ion showing complete electron shells and a charge of + 1<br><br>i.e.<br>  <br><br>(1)<br><br>one oxide ion drawn with 8 electrons in outer shell and charge of –<br>  <br><br>(1) | 2 | **allow** electrons drawn as all dots or all crosses<br>**allow** correct structures without brackets<br>**ignore** inner shells<br><br>**not** $(Na_2)^{2+}$ or $(Na)_2^{2+}$<br>**allow** $Na^+$ or $2(Na)^+$ or $(Na^+)_2$ or two sodium ions drawn<br><br>**if the electrons lost by sodium atoms are drawn more than once, answer scores zero if this is the only diagram shown** eg either on the oxide ion outer shell or on the sodium atom(s) with an arrow showing it / them being transferred to the oxygen atom<br><br>**if a covalently bonded structure is shown in the diagram answer scores 0, but if covalent in the writing and correct diagram then ignore writing**<br>**not** $O_2^{2?}$<br><br>**allow** a maximum of one mark for either: correct electronic structure of sodium ion and oxide ion (1)<br>**or** correct charges on ions – this is independent of the electronic structures drawn eg $Na^+$ $O^{2?}$ (1)<br><br>**Examiner's Comments**<br><br>The sodium ion was the most accurately written with the correct electronic structure and charge. Other candidates failed to score by showing donated electrons on both ions or drawing a covalent structure. Some candidates drew the electronic configuration of the original element atoms. |
| | | | **Total** | **5** | |

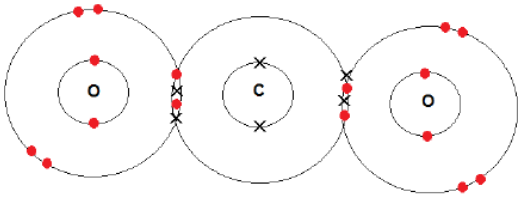
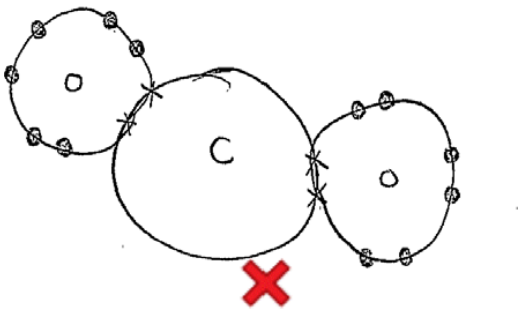
| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 12 | | | Level 3 (5-6 marks)<br>Candidate produces a detailed description of the wor of both Dobereiner and Newlands.<br><br>Quality of written communication does not impede communication of the science at this level.<br><br>Level 2 (3-4 marks)<br>Candidate produces a detailed description of the work of either Dobereiner or Newlands<br><br>*OR*<br><br>a partial description of the work of both.<br>Quality of written communication partly impedes communication of the science at this level.<br><br>Level 1 (1-2 marks)<br>Candidate produces a partial description of the work of either Dobereiner or Newlands.<br><br>Quality of written communication impedes communicatio of the science at this level.<br><br>Level 0 (0 marks)<br>Insufficient or irrelevant science. Answer not worthy of credit. | 6 | This question is targeted at grades up to C.<br>Indicative scientific points may include:<br><br>Dobereiner<br><br>• triads consist of three elements<br>• recognised groups of elements<br>• identified patterns between elements with similar properties<br>• middle one of triad has a relative atomic mass which is the average of the other two<br>• identifies triads eg Li, Na and K **or** F, Cl and Br **or** Ca, Sr and Ba **or** S, Se and Te.<br><br>Newlands<br><br>• arranged elements in order of their relative atomic mass<br>• elements with similar chemical properties were 8 positions away from each other<br>• this is similar to musical notes in an octave<br>• noble gases not yet discovered<br>• pattern does not work for all elements.<br><br>Use the L1, L2, L3 annotations in scoris. Do not use ticks.<br><br><u>Examiner's Comments</u><br><br>A significant proportion of candidates did not attempt this question and most candidates appeared not to have covered this aspect of the How Science Works / Chemistry content of the specification. Many candidates simply restated the information given in the question, i.e. Dobereiner noticed triads and Newlands developed the law of octaves, and failed to gain credit. |
| | | | Total | 6 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 13 | | | Level 3 (5–6 marks)<br>Answer includes a piece of evidence used by both<br>AND<br>includes an idea used by Newlands and an idea used<br>by Mendeleev.<br>Quality of written communication does not impede communication of the science at this level.<br><br>Level 2 (3–4 marks)<br>Answer includes a piece of evidence used by both<br>and includes an idea used by Newlands or Mendeleev<br>OR<br>answer includes an idea used by Newlands and an<br>idea used by Mendeleev<br>Quality of written communication partly impedes communication of the science at this level.<br><br>Level 1 (1–2 marks)<br>Answer includes a piece of evidence used by both<br>OR<br>includes an idea used by EITHER Newlands or Mendeleev<br>Quality of written communication impedes communication of the science at this level.<br><br>Level 0 (0 marks)<br>Insufficient or irrelevant science. Answer not worthy of credit. | 6 | This question is targeted at grades up to A.<br><br>Indicative scientific points may include:<br><br>Evidence used by both:<br><br>• arranged elements so that elements with similar chemical properties / reactivity were grouped together<br>• arranged elements in order of their (atomic) mass<br><br>Newlands:<br><br>• realised elements with similar chemical properties were 8 positions away from each other<br>• this is similar to musical notes in an octave<br>• pattern does not work for all elements<br><br>Mendeleev:<br><br>• left gaps for elements not yet discovered<br>• accurately predicted the properties of elements yet to be discovered<br>• ignored hydrogen as it did not fit pattern<br>• realised that not all elements had been discovered<br><br>Use the L1, L2, L3 annotations in scoris. Do not use ticks.<br><br>Examiner's Comments<br><br>The best answers here included references to the similarities between Newland's and Mendeleev's approach and the differences. The differences often included Newlands ‘octaves’ and Mendeleev's ‘gaps’. The factual recall required in this question was found very challenging and there were many incorrect references to electron shells and protons. |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | Total | 6 | |
| 14 | | | closely packed metal ions (1)<br><br>in a sea of electrons / with free electrons / with delocalised electrons (1)<br><br>  <br> | 2 | **not** intermolecular forces / covalent bonding / ionic bonding / (metal) molecules = 0 for the question<br><br>**ignore** atoms<br>**allow** positive atoms, cations, positive ions instead of metal ions<br><br>marks can be awarded from a **labelled** diagram<br>needs to be minimum of six ions to score metal ion mark<br><br><u>Examiner's Comments</u><br><br>There are still many candidates that are referring to covalent or intermolecular bonds when trying to describe metallic bonding. There were some good, labelled diagrams but even then some were contradicted in prose. |
| | | | Total | 2 | |
| 15 | | i | $H_2 + Cl_2 \rightarrow 2HCl$<br><br>formulae (1)<br>balancing (1) | 2 | **allow** = instead of arrow<br><br>**not** and or & instead of +<br><br>**allow** correct multiples of this equation including fractions<br><br>**allow** one mark for balanced equation with minor errors in case and subscript e.g. H2 + CL2 → 2HCl |
| | | ii |  <br><br>(1) | 1 | **allow** all dot or all crosses<br>**allow** clear indication of shared pair of electrons drawn without orbits drawn<br>**ignore** inner electrons in chlorine<br><br>atoms must be labeled<br>**not** if charges are included |
| | | | Total | 3 | |

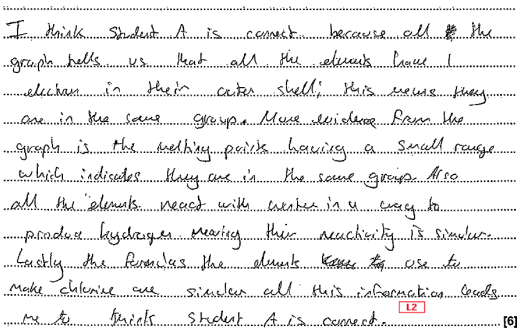
| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 16 | a | | silver (1) | 1 | **allow** Ag (1) |
| | b | | yes since it is in the middle or centre of the Periodic Table (1) | 1 | must have yes **and** explanation for the mark<br><br>**allow** yes since it lies between Groups 2 and 3 in the Periodic Table (1)<br>**allow** yes because it is not in a Group (1)<br>**allow** yes because it lies between two named transition elements |
| | | | **Total** | 2 | |
| 17 | a | |  **Or** $Na^+$ (1)<br>  (1) | 2 | **allow** all dot or all crosses<br><br>**ignore** inner electrons in both ions<br><br>if same electron shown in both ions then max 1 for question eg the same electron at either end of an arrow<br><br>if electrons shared then zero for the question<br><br>ions must be labelled<br><br>if no marks awarded give **one** mark for **both** charges correct |
| | b | | giant structure / many bonds / a lattice (1)<br><br>strong (ionic) bonds / bonds need lots of energy to break / bonds need a high temperature to break (1) | 2 | **no marks** in question if intermolecular or covalent bonds or metallic bonding is referred to |
| | | | **Total** | 4 | |
| 18 | | | (by two atoms) sharing (a pair of) electrons (1) | 1 | **not** two molecules sharing (a pair of) electrons |
| | | | **Total** | 1 | |
| 19 | | | ionic (1) | 1 | **allow** electrovalent (1)<br>**allow** metallic (1)<br><br>**ignore** ion bonding / metal bonding / double bonds / single bonds |
| | | | **Total** | 1 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 20 | | | One shared pair of electrons correctly shown ✓<br><br>Rest of structure correct ✓ | 2<br>(AO2 × 2.2) | Electrons on inner two shells NOT required but **must be correct if shown**<br>Lone pair of electrons do not need to be together<br><br>**ALLOW** all dots, all crosses or a mixture of dots and crosses<br><br>  <br><br><br><u>Examiner's Comments</u><br>Many candidates gained one mark for showing a shared pair of electrons, but fewer were able to complete the rest of the diagram successfully. Some attempted an ionic structure or a stick diagram. Many candidates did not attempt this question. |
| | | | Total | 2 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 21 | | | 2 shared pairs of electrons between carbon and one oxygen atom ✓<br><br>Rest of structure correct ✓ | 2 (AO 2 ×2.1) | Inner electrons not required but must be correct if shown.<br>**ALLOW** all dot, all crosses or mixture of dots and crosses.<br>  <br><br><br>Examiner's Comments<br><br>Candidates' responses were generally not creditworthy. Almost all candidates attempted covalent dot and cross diagrams (a very small number were ionic). Errors included insufficient numbers of electrons involved in the two double covalent bonds, choosing instead to give single bonds between carbon and oxygen and placing pairs of electrons on the ring of carbon. Lower ability candidates gave the wrong formula for the molecule of carbon dioxide, usually CO rather than CO2.Almost all candidates did use the 'dot and cross' symbols as directed in the question. Centres could perhaps encourage candidates to do a quick check of full shells to ensure their diagrams are feasible.<br><br>Exemplar 8<br><br>  <br><br><br>Dot and cross diagrams were generally well drawn but as you can see from this example the candidate has ensured the oxygen atoms have 8 electrons in their |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | | | outer shell but unfortunately no electrons are shared so carbon only has 4 electrons in its outer shell. |
| | | | Total | 2 | |
| 22 | | | Any **two advantages** from:<br><br>**A and / or C** shows number and type of atoms ✓<br>**A and / or C** shows type of bonds ✓<br>**B and / or C** shows how the atoms are connected in 3D (tetrahedral) ✓<br>**B shows the comparative size of the atoms** ✓<br><br>Any **two disadvantages** from:<br><br>**A** only 2D ✓<br>**A and / or C** no indication of size of atoms ✓<br>**B** does not show number and type of atoms ✓<br>**B** does not show type of bonds ✓ | 4 (AO 2 × 3.1a)<br><br>(AO 2 × 3.1b) | <u>Examiner's Comments</u><br><br>This question was generally well answered by candidates. The difficulty seemed to be in communicating their ideas in a scientific way. The diagrams clearly have scientific merit and the candidates were essentially asked to compare the merit of the diagrams.<br><br>Candidates often commented on which they though was the 'best' diagram but this was not asked for in the question. Ideas about the relative size of the atoms and the type of bonding were seen less frequently than ideas about the 2D and 3D nature of the diagrams or the number and types of atoms present. |
| | | | Total | 4 | |
| 23 | | | **Any two from:**<br><br>Transfer of electrons from metals to non-metals ✓<br><br>Metals form positive ions and non-metals form negative ions ✓<br><br>Electrostatic forces / attraction between oppositely charged ions✓ | 2 (AO 2 ×1.1) | <u>Examiner's Comments</u><br><br>This question was only answered well by the very high ability candidates. They often identified there was a transfer of electrons but did not show which element (metal or non-metal) lost or gained the electrons. The idea of electrostatic attraction between oppositely charged ions was rarely seen. Responses were often confused. |
| | | | Total | 2 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 24 | | | Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.<br>**Level 3 (5–6 marks)**<br>**Provides a detailed explanation of the evidence to support both conclusions**<br>**AND**<br>**States whose conclusion is correct with valid reasons**<br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>**Explains the evidence that supports both student A's and student B's conclusion**<br>**OR**<br>**States whose conclusion they think is correct quoting valid reasons**<br>*There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>**Quotes evidence to support student A's OR student B's conclusion**<br>**OR**<br>**States whose conclusion they think is correct with a valid reason**<br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>*No response or no response worthy of credit.* | **6 (AO 1 × 1.1) (AO 2 × 2.1) (AO 2 × 3.1a) (AO 1 × 3.2b)** | **AO1.1 Demonstrates knowledge and understanding of the groups on the Periodic Table**<br>• same number of electrons in outer shell means elements in the same group<br><br>**AO2.1 Applies knowledge and understanding of Group properties**<br>• element **Y is sodium and X is lithium and Z** is potassium / rubidium<br><br>**AO3.1b Analyses information to interpret evidence from the table**<br>Supporting student A's conclusion<br>• melting points show a downward trend as Group is descended<br>• similar reaction with water<br>• formula of chlorides is the same<br><br>Supporting student B's conclusion<br>• density shows no clear trend / densities go up and then down again<br>• action of heat on carbonates shows no clear trend or reactions are different<br>• melting points of chlorides show an increase then a decrease as Group is descended<br><br>**AO3.2b Analyses information to draw conclusions based on the analysis**<br>• Student A is correct as same number of electrons in outer shell<br>• Student A is correct as most evidence supports his viewpoint<br>• Student B is correct as not all the evidence supports the idea that the elements are in the same group<br><br>Examiner's Comments<br><br>Many candidates appreciated that candidate A could be correct as all three elements had 1 electron in their outer shell. |

| Question | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|
| | | | Many thought this was sufficient evidence and so did not undertake any further discussion of information in the table or Student B. Those that used the reaction with water as evidence for Student A often just had the elements reacting with water rather than reacting similarly. Some named the elements from their atomic numbers but many thought that the different atomic numbers supported Student B.<br>Many thought the reactions with water were different and so supported Student B. Some candidates discussed the different reactions of heat on the carbonates to be evidence in support of Student B. Many thought that different melting points and densities supported Student B rather than considering trends in these properties.<br>Very few considered the chlorides either in terms of melting point or formula.<br>A significant number omitted the question.<br><br>Exemplar 1<br>  <br>I think Student A is correct because all the graph tells us that all the elements have 1 electron in their outer shell, this means they are in the same group. Also similar from the graph is the melting point having a small range which indicates they are in the same group. Also all the elements react with water in a way to produce hydrogen making their reactivity is similar. Lastly the formulas the elements have to use to make chlorine are similar all this information leads me to think Student A is correct. L2 [6]<br><br>The candidate has chosen Student A as being correct and has cited several pieces of evidence from the table to support this choice. (The evidence cited: all have 1 electron in their outer shell, all react with water to produce hydrogen and the formulae of the chlorides are all similar.)<br>This answer fulfils Level 2 in the OR statement of the mark scheme. There is a choice of conclusions, there is sufficient supporting evidence within a structured line of reasoning.<br>The question asks the candidate to analyse and explain the information that supports both Student A's and Student B's conclusions and decide who they think is |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | | | correct.<br>In order for this answer to move into Level 3, the candidate needs to consider the evidence which could support Student B e.g. there is no clear trend in melting point or density or the reaction of heat on the carbonates are different. |
| | | | Total | 6 | |