CS C1 H Ionic, covalent and metallic bonding

Date:

Time: 39 minutes
Total marks available: 39
Total marks achieved: ______
Questions

Q1.

Chlorine and carbon

(a) Chlorine has an atomic number of 17. Chlorine-35 and chlorine-37 are two isotopes of chlorine.

(i) Complete the table to show the numbers of protons, neutrons and electrons in each of the isotopes.

<table>
<thead>
<tr>
<th></th>
<th>chlorine-35</th>
<th>chlorine-37</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of protons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>number of neutrons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>number of electrons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) A normal sample of chlorine contains only chlorine-35 and chlorine-37 atoms. Explain why the relative atomic mass of chlorine is 35.5

(b) Tetrachloromethane is a simple molecular, covalent compound. The formula of its molecule is CCl₄.

There are four electrons in the outer shell of a carbon atom.
There are seven electrons in the outer shell of a chlorine atom.
Draw a dot and cross diagram to show the bonding in a molecule of tetrachloromethane, CCl₄.
Show outer shell electrons only.
The diagrams show the arrangements of carbon atoms in diamond and in graphite.

Compare a use of diamond with a use of graphite, explaining each use in terms of the bonding and structure. In your answer you should use information from the diagrams.

(Total for question = 12 marks)
Q2.

Figure 13 shows a model of how particles are arranged in a solid.

Figure 13

State two ways in which this model fails to accurately represent a crystal of sodium chloride.

1 .......................................................................................................................................................
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2 .......................................................................................................................................................
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(Total for question = 2 marks)

Q3.

Lithium fluoride, LiF, is an ionic compound.

It contains lithium cations and fluoride anions.

The electronic configurations of a lithium atom and of a fluorine atom are shown in Figure 6.

Figure 6

Complete Figure 7 to show the electronic configurations and charges of the ions in lithium fluoride.
Q4.

Magnesium oxide has a melting point of 2852 °C.

Explain why magnesium oxide has such a high melting point.

(Total for question = 3 marks)

Q5.

Metals

There are many metallic elements in the periodic table.
(a) Which row of the table correctly shows two metals that are in group 1 and two metals that are transition metals?

Put a cross (X) in the box next to your answer.

<table>
<thead>
<tr>
<th>group 1</th>
<th>transition metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>A lithium and zinc</td>
<td>calcium and copper</td>
</tr>
<tr>
<td>B potassium and caesium</td>
<td>copper and iron</td>
</tr>
<tr>
<td>C sodium and potassium</td>
<td>copper and magnesium</td>
</tr>
<tr>
<td>D sodium and magnesium</td>
<td>manganese and nickel</td>
</tr>
</tbody>
</table>

(b) (i) Describe the structure of metals in terms of the particles present in their structures.

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(ii) Explain how metals conduct electricity.

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(c) (i) Describe what you would see when a small piece of sodium is added to water.

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(ii) Write the balanced equation for the reaction of sodium with water to form sodium hydroxide and hydrogen.

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Q6.

Nitrogen and oxygen are present in the air.
(a) In industry, nitrogen and oxygen are obtained from air.
(i) Give the name of the process used.
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(a)(ii)
This proved to be a challenging question. Many scored one mark but only the strongest candidates scored both marks. The idea of RAM as an average mass was appreciated by many candidates, but there was a substantial minority who tried to explain the non-integer value with half a neutron. Many candidates made non-specific comments about abundances of isotopes but failed to say that Cl-35 was the most abundant. Others incorrectly stated that 35.5 was half way between 35 and 37 or that it should be 36, but 36 doesn't exist and so it's given as 35.5! Some of the best candidates were able to use a calculation method to work out how to get 35.5 as the mean value.
(ii) A normal sample of chlorine contains only chlorine-35 and chlorine-37 atoms.

Explain why the relative atomic mass of chlorine is 35.5

Because there is a higher amount of chlorine-35 which is 35, which means the relative atomic mass would be closer to 35 than 37.

Results Plus: Examiner Comments
This was worth one mark for indicating there is more Cl-35 but there is no mention of average.

(ii) A normal sample of chlorine contains only chlorine-35 and chlorine-37 atoms.

Explain why the relative atomic mass of chlorine is 35.5

Because it contains some chlorine-35 and chlorine-37 atoms, so by doing $3 \times 35 = 105 + 37 = 142$, $142 \div 4 = 35.5$.

So the relative atomic mass of chlorine is 35.5.

Results Plus: Examiner Comments
This answer is worth both marks by correctly using a calculation type approach.

(ii) A normal sample of chlorine contains only chlorine-35 and chlorine-37 atoms.

Explain why the relative atomic mass of chlorine is 35.5

75% of chlorine atoms are 35, while only 25% are 37, so when you calculate the relative atomic mass by $(3.5 \times 35) + (3.7 \times 25) = 3.550$.

$3.550 \div 1.00 = 35.5$ which is the relative atomic mass.
Results Plus: Examiner Comments
Another calculation method worth both marks.

(b)
The majority of candidates gave fully correct electron structures. Those who did not often gave the incorrect number of atoms (despite having been given the chemical formula), had the atoms linked in a row, or drew ionic structures. A few candidates made careless errors such as missing out an electron in one of the shared pairs and subsequently forfeited both marks.

(b) Tetrachloromethane is a simple molecular, covalent compound. The formula of its molecule is $\text{CCl}_4$.
There are four electrons in the outer shell of a carbon atom.
There are seven electrons in the outer shell of a chlorine atom.
Draw a dot and cross diagram to show the bonding in a molecule of tetrachloromethane, $\text{CCl}_4$.
Show outer shell electrons only.

Results Plus: Examiner Comments
This answer was worth one mark for correctly showing four pairs of electrons being shared despite there being no symbols given.
(b) Tetrachloromethane is a simple molecular, covalent compound. The formula of its molecule is CCl₄.

There are four electrons in the outer shell of a carbon atom. There are seven electrons in the outer shell of a chlorine atom.

Draw a dot and cross diagram to show the bonding in a molecule of tetrachloromethane, CCl₄.

Show outer shell electrons only.

Results Plus: Examiner Comments
A fully correct answer worth both marks.
Answers like this were quite common despite the correct formula having been given in the question. It obviously gained no marks.

(c)
It was very pleasing to see so many good answers to this question with about three quarters of candidates gaining a Level 2 or 3. However some had not read the question carefully which asked for a comparison of a use for diamond and a use for graphite with relevant explanations in terms of the bonding and structure, and so credit was only given for one use or property of each. Candidates had a very good idea of the uses and properties of graphite and the linked explanations. They were less strong on those of diamond, with many just restating that diamond has strong bonds, which they had been told in the question and so did not attract credit. Others did not link their good explanations to a property or use, so limiting the mark they gained. Some suggested a use of graphite as kitchen work surfaces or as a building material, suggesting they were thinking of granite. Significant numbers incorrectly used the term intermolecular forces/bonds in their descriptions of diamond and graphite.
A use of graphite is pencils. As it has weak attractive forces the sheets slide over each other so the graphite fragments can be cut off easily. Whereas a diamond is used for cutting stones, metals and other gems. Diamonds cannot do this as they have strong bonds, making it dense.
*(c) The diagrams show the arrangements of carbon atoms in diamond and in graphite.

\[ \text{diamond} \]

\[ \text{graphite} \]

Compare a use of diamond with a use of graphite, explaining each use in terms of the bonding and structure. In your answer you should use information from the diagrams.

Both diamond and graphite are giant molecular covalent structures. Diamond is made of thousands of carbon atoms and has very strong covalent bonds between the atoms. It is very hard and does not conduct electricity. Diamond is therefore used for cutting tools as it does not break easily and it is stronger than for this purpose. Graphite is made of layers of carbon atoms also held together by covalent bonds. Graphite is softer than diamond and can conduct electricity as there is one delocalized electron from each carbon atom which is able to move between layers, and thus conduct electricity. Graphite is therefore used as a lubricant as the layers of carbon atoms can slide over each other easily and it is also used to move electrodes as it can conduct electricity.

(Total for Question 5 = 12 marks)

Results Plus: Examiner Comments
This response was one of the many which were worthy of Level 3 and 6 marks.
*(c) The diagrams show the arrangements of carbon atoms in diamond and in graphite.

\[ \text{\bullet = carbon atom} \]

**Strong bonds**

![Diagram of diamond and graphite arrangements]

Compare a use of diamond with a use of graphite, explaining each use in terms of the bonding and structure. In your answer you should use information from the diagrams.

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Results Plus: Examiner Comments
This response contains a correct property of graphite (and diamond) but there are no relevant explanation points so it was awarded Level 1 and 2 marks.

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Q2.
No Examiner's Report available for this question

Q3.
No Examiner's Report available for this question

Q4.
No Examiner's Report available for this question
Q5.

(b)(i)
The concept of delocalised electrons was quite common but a considerable numbers of candidates failed to mention cations or positive ions when answering this question. Some candidates thought metals contained positive and negative ions. Others mentioned protons instead of positive ions. Many candidates described the arrangement of particles in a metal and went on to describe how the arrangement explained the physical properties of a metal, but without mentioning that the particles are positive ions.

Results Plus: Examiner Comments
This candidate gained one mark for a correct reference to delocalised electrons but, like many others, wrote protons rather than cations/positive ions.

(b)(ii)
Most students were able to identify electrons as being involved in metals conducting electricity. Many were also able to explain that this was because the electrons were free to move and so gained both marks. However a proportion of candidates referred to "charged particles" instead of
electrons.

Others confused the conductivity of metals with that of ionic substances with references made to ions or that the metal had to be molten to conduct.

Results Plus: Examiner Comments
This gained one mark for correctly identifying the involvement of electrons, but unfortunately did not mention the idea of them moving so did not gain the second mark.

Results Plus: Examiner Comments
An example of a response indicating that electrons are free to move and so worth both marks.

(c)(i)

The reaction between sodium and water was very well described by most candidates indicating the value of teacher demonstrations, however some candidates did not appreciate that the question was asking for things that can be seen during the reaction. Comments on the reactivity of sodium or explaining its reactivity in terms of electron arrangement are not required. Candidates should realise that "fizzing" and "bubbling" are really the same observation and that "hydrogen is given off" is not an observation. A few candidates included observations made after adding universal indicator, which were not credited.

(c)(ii)

About 30% of candidates produced a fully correct balanced equation. Most commonly candidates
scored just one mark for the formulae on the left hand side of the equation, which was meant to be a straightforward mark. Given that the products were also named in the question, it was very disappointing that so few candidates were able to score the second mark. H for hydrogen was common as was sodium hydroxide being given as Na(OH)$_2$.

It was also very surprising to see the introduction of substances not mentioned in the question.

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Results Plus: Examiner Comments
This candidate was awarded two marks as the symbols and formulae are correct on both sides of the equation but the equation has not been balanced.

Results Plus: Examiner Comments
Although it should obviously not be encouraged the use of brackets around OH was not penalised. Candidates who wrote NaHO were treated in a similar way.

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Q6.

(a) (i)
Fractional distillation was correctly given by about two thirds of candidates but some omitted the word fractional.

(a) (ii)
Although many candidates gave a correct answer, quite frequently in terms of removing water or carbon dioxide, there were a surprising number of misconceptions including those who thought cooling was to remove dust particles and others simply stated that cooling the air would make it all the same temperature. Others tried to bring in rates of reaction and talked about a lower
temperature stopping the air reacting.

(c) (i)

Many candidates scored 1 mark for stating that covalent bonding involves the sharing of electrons, but they usually failed to gain the second mark for stating that a pair of electrons are shared.

Results Plus: Examiner Comments
A typical answer worth one mark.

(c) (ii)

The large majority of candidates gave the correct configuration.

(c) (iii)

Most scored a mark for correctly showing a shared pair of electrons in a molecule of carbon dioxide. A common error was to show single bonds between the atoms rather than double bonds and a few candidates who did show double bonds lost marks by putting extra electrons on carbon and/or oxygen. Some candidates lost both marks as they failed to draw a correct CO$_2$ molecule, CO was often seen and sometimes COC.

Results Plus: Examiner Comments
A well drawn answer for two marks.
Results Plus: Examiner Comments
An answer worth 1 mark for showing a shared pair of electrons in a CO₂ molecule.

Mark Scheme
Q1.
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answers</th>
<th>Acceptable Answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)(i)</td>
<td></td>
<td>chlorine-35</td>
<td>chlorine-37</td>
</tr>
<tr>
<td>number of protons</td>
<td>17</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>number of neutrons</td>
<td>18</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>number of electrons</td>
<td>17</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>the four 17s (1)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>the 18 and 20 (1)</td>
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</table>

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answers</th>
<th>Acceptable Answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)(ii)</td>
<td>An explanation linking</td>
<td>mean ignore weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M1 average (mass of atoms/isotopes present) (1)</td>
<td>75% chlorine-35 / 25% chlorine-37/ chlorine-35 and chlorine-37 in ratio 3:1 / correct calculation to obtain 35.5 (2) eg[(75x35) + (25x37)]/100</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answers</th>
<th>Acceptable Answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>Diagram showing one carbon and four chlorines</td>
<td>use of dots or crosses or mixture of both ignore inner shells even if incorrect ignore symbols</td>
<td></td>
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<tr>
<td></td>
<td>four pairs of electrons shared between the carbon and chlorine atoms (1)</td>
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<td></td>
<td>fully correct (1)</td>
<td></td>
<td>(2)</td>
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<tr>
<td>Question Number</td>
<td>Indicative Content</td>
<td>Mark</td>
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<td>-----------------</td>
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<tr>
<td>QWC * (c)</td>
<td>A response including some of the following points</td>
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<tr>
<td></td>
<td>Note: (carbon to carbon) strong bonds is given in question</td>
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<tr>
<td></td>
<td>Diamond:</td>
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<td></td>
<td>Uses and Properties</td>
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<tr>
<td></td>
<td>• in cutting tools/engraving</td>
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<td>• drill bit</td>
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<tr>
<td></td>
<td>• jewellery</td>
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<tr>
<td></td>
<td>• diamond very hard/strong</td>
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<td></td>
<td>• attractive/lustrous</td>
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<td>• high melting point</td>
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<td>Explanations</td>
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<td></td>
<td>• giant molecular/covalent</td>
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<td></td>
<td>• each carbon atom bonded to four other carbon atoms</td>
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<td>• three dimensional structure</td>
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<td>• to break it lots of bonds would need to be broken</td>
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<td></td>
<td>• would need lot of energy/force</td>
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<td></td>
<td>Graphite:</td>
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<tr>
<td></td>
<td>Uses and Properties</td>
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<td></td>
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<tr>
<td></td>
<td>• to make electrodes</td>
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<td></td>
<td>• a lubricant</td>
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<td>• sporting equipment</td>
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<td>• in pencils/drawing</td>
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<td></td>
<td>• graphite conducts electricity</td>
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<td>• soft</td>
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<td>Explanations</td>
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<td></td>
<td>• giant molecular/covalent</td>
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<td></td>
<td>• each carbon atom bonded to three other carbon atoms</td>
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<td></td>
<td>• each carbon atom has a free electron</td>
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<td></td>
<td>• delocalised electrons</td>
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<tr>
<td></td>
<td>• (delocalised) electrons move to carry current</td>
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<td></td>
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<tr>
<td></td>
<td>• layers of carbon atoms</td>
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<tr>
<td></td>
<td>• weak forces/bonds between layers/sheets</td>
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<tr>
<td></td>
<td>• so layers/sheets can slide/rub off or over each other</td>
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<td></td>
</tr>
</tbody>
</table>

(6)
<table>
<thead>
<tr>
<th>Level</th>
<th>0</th>
<th>No rewardable content</th>
</tr>
</thead>
</table>
| 1     | 1 - 2 | - a limited description  
|       |       |   eg for either diamond or graphite  
|       |       |   states a correct Use or Property  
|       |       |   - the answer communicates ideas using simple language and uses limited scientific terminology  
|       |       |   - spelling, punctuation and grammar are used with limited accuracy  
| 2     | 3 - 4 | - a simple description/explanation  
|       |       |   eg for both diamond and graphite  
|       |       |   states a correct Use or Property linked with at least one relevant explanation point  
|       |       | **OR**  
|       |       |   for either diamond or graphite  
|       |       |   States a correct Use or Property linked with at least two relevant explanation points  
|       |       |   - the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately  
|       |       |   - spelling, punctuation and grammar are used with some accuracy  
| 3     | 5 - 6 | - a detailed explanation  
|       |       |   eg for both diamond and graphite  
|       |       |   States a correct Use or Property linked to at least three relevant explanation points (in total)  
|       |       | **OR**  
|       |       |   for either diamond or graphite  
|       |       |   States a correct Use or Property linked to at least four relevant explanation points (in total)  
|       |       |   - the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately  
|       |       |   - spelling, punctuation and grammar are used with few errors  

**Q2.**

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Additional guidance</th>
<th>Mark</th>
</tr>
</thead>
</table>
|                 | • particles are same size when they should be different sizes (1)  
|                 | • model is in 2D but crystal is 3D (1) | Allow reverse statements giving correct information. | (2) |

**Q3.**
<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
</tr>
</thead>
</table>
| Q4.             | - Li ion with empty outer shell (1)  
|                 | - 1+ charge on Li (1)  
|                 | - 8 electrons on outer shell of F (1)  
|                 | - 1− charge on F (1)  

(4)

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
</tr>
</thead>
</table>
| Q4.             | An explanation that combines identification – knowledge (1 mark) and reasoning/justification – understanding (2 marks):  
|                 | - very strong bonds/ionically bonded (1)  
|                 | - between 2+ cations and 2− anions (1)  
|                 | - so requires lot of energy to separate magnesium and oxide ions to melt the solid (1)  

(3)

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
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<tbody>
<tr>
<td>Q5.</td>
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<tr>
<td>Question Number</td>
<td>Answer</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>(a)</td>
<td>B potassium and caesium, copper and iron</td>
</tr>
<tr>
<td>(b)(i)</td>
<td>A description linking (regular arrangement of) positive ions /cations (1) (surrounded by) {delocalised/sea of} electrons (1)</td>
</tr>
<tr>
<td>(b)(ii)</td>
<td>An explanation linking M1 electrons (1) M2 move/flow (1) M2 dep on M1</td>
</tr>
</tbody>
</table>
Q6.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)(i)</td>
<td>fractional distillation</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>(a)(ii)</td>
<td>to make it liquid</td>
<td>liquefy/condense to remove water (vapour) to remove carbon dioxide</td>
<td>(1)</td>
</tr>
<tr>
<td>(b)</td>
<td>D weak forces of attraction between the oxygen molecules</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>(c)(i)</td>
<td>An description including • shared (electrons) (1) • pair(s) of electrons (between atoms) (1)</td>
<td>Ignore reference to complete/full shells Ignore reference to between two metals Ignore reference to between metal and non-metal</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ignore reference to between molecules Any reference to between ions scores 0</td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td></td>
</tr>
<tr>
<td>(c)(ii)</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c)(iii)</td>
<td>diagram showing any shared pair of electrons between a carbon and oxygen atom in CO&lt;sub&gt;2&lt;/sub&gt; molecule (1) • rest of molecule correct (1)</td>
<td>Must have O CO arrangement If any atom labelled must be correct Ignore inner electrons even if wrong electrons can be on/in ring or no ring Ignore intersecting circles Accept all permutations of dots and crosses (2)</td>
<td></td>
</tr>
</tbody>
</table>