GCSE · AQA · Chemistry

2 hours 20 questions

Exam Questions

Bonding & Substance Properties

States of Matter / Particle Theory & its Limitations / State Symbols / Properties of Ionic Compounds / Properties of Small Molecules / Polymers / Giant Covalent Structures / Properties of Metals & Alloys / Metals as Conductors

Easy (5 questions)	/38
Medium (10 questions)	/51
Hard (5 questions)	/49
Total Marks	**/138**

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Easy Questions

1 (a) This question is about states of matter.

Table 1 shows the melting and boiling points of some of the elements in Group 7.

Table 1

Element	Melting point in °C	Boiling point in °C
Fluorine	–220	–188
Chlorine	–101	–35
Bromine	–7	59

Give the state of each substance at 50 ^{o}C

Fluorine: _____

Chlorine:_____

Bromine:_____

Answer

The states of the substances are:

- Fluorine: gas; [1 mark]
- Chlorine: gas; [1 mark]
- Bromine: liquid; [1 mark]

[Total: 3 marks]

- The boiling point is the point at which the substance turns from a liquid to a gas
- The boiling points of fluorine and chlorine are both below 50 ^{O}C so they are gases
- Bromine turns into a gas at 59 ^{O}C and therefore at 50 ^{O}C will still be a liquid

(3 marks)

(b) Use the information from **Table 1** to complete the sentence:

Going down group 7, the melting points _____.

This is because the size of the molecules _____ so the forces between the molecules get _____.

Answer

The completed sentences are:

Going down group 7, the melting points **increase**.

This is because the size of the molecules **increases,** so the forces between the molecules get **stronger.**

- Increase; [1 mark]
- Increases; [1 mark]
- Stronger; [1 mark]

[Total: 3 marks]

(3 marks)

(c) A solution of potassium bromide will react with lead nitrate in the following reaction:

$$Pb(NO_3)_2\,(aq) + 2KBr\,(aq) \rightarrow 2KNO_3\,(aq) + PbBr_2\,(s)$$

What information does the equation tell you about the products made in this reaction?

Answer

The information we can deduce is:

- Potassium nitrate; [1 mark]
- Is aqueous / in solution / dissolved in water; [1 mark]
- Lead bromide; [1 mark]
- Is a solid; [1 mark]

[Total: 4 marks]

- State symbols indicate the state a substance is in
- They include (s) solid, (l) liquid, (g) gas, and (aq) aqueous which is when a solution is dissolved in water

(4 marks)

2 (a) This question is about magnesium.

Magnesium can be shaped easily.

Tick (✓) **two** reasons which explain why metals can be shaped.

Reason why:	**Tick**
The atoms are all joined by ionic bonds.	
The atoms can slide over each other.	
The atoms are small.	
The atoms are in layers.	

Answer

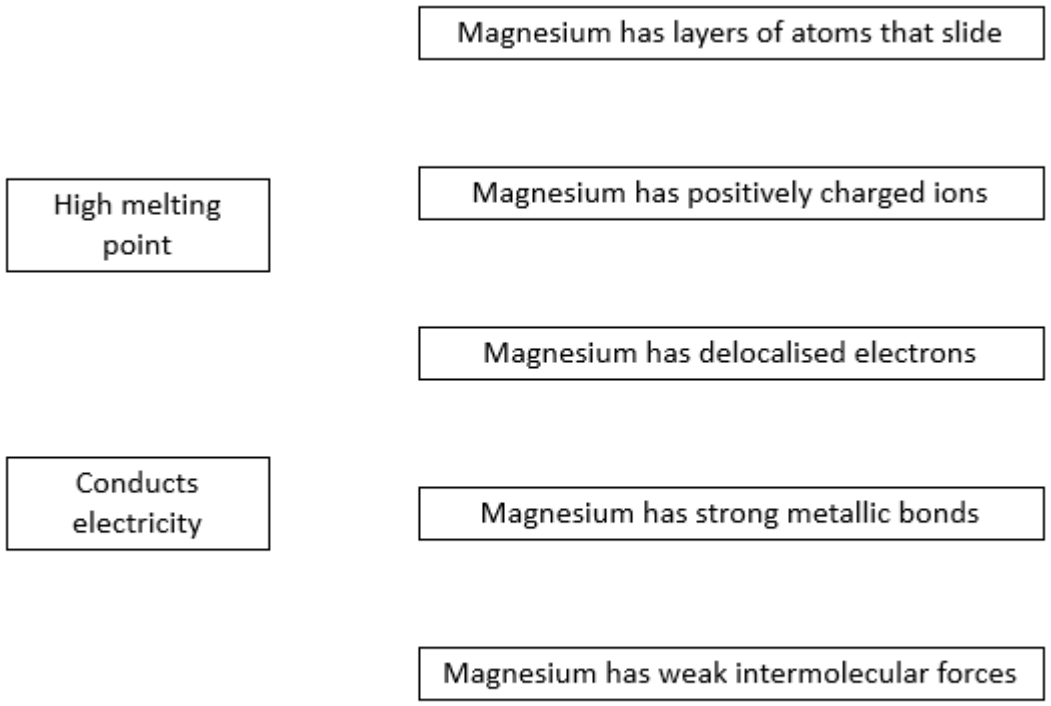
Metals can be easily shaped because:

- The atoms are in layers; [1 mark]
- The atoms can slide over each other: [1 mark]

[Total: 2 marks]

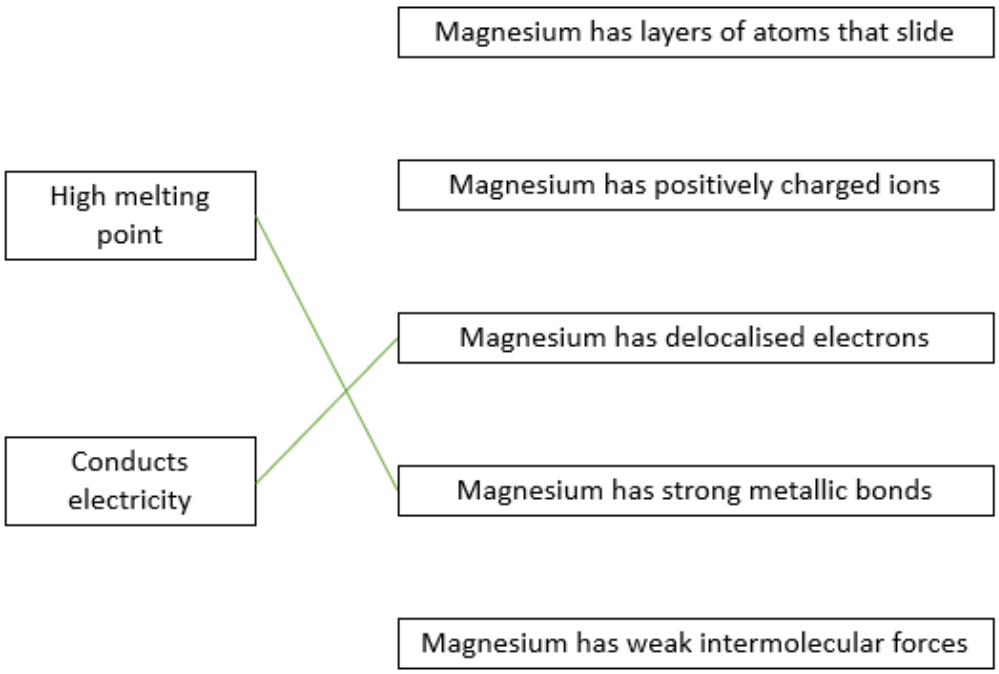
(2 marks)

(b) Draw a line to match the following properties of magnesium with the correct explanation.



Answer

The correct pairs are:



- Correctly matches high melting point; [1 mark]
- Correctly matches delocalised electrons; [1 mark]

[Total: 2 marks]

- You must only have **one** line from each box on the left – if there is more than one, this negates the mark
- The strong metallic bonds are between the positive metal ions and the delocalised electrons
- Lots of energy is needed to overcome this attraction hence the high melting point
- One common mistake is identifying whether electrons or ions are moving and carrying a charge
    - Ions are only moving if the substance has ionic bonding and is molten or in solution

- In all other cases, the electrons are moving and carrying the charge

(2 marks)

(c) What is meant by an alloy?

Answer

An alloy is:

- (an alloy is) a mixture of elements, one of which is a metal

  allow (an alloy is) a mixture of (two or more) metals

  alloy (an alloy is) a mixture of a metal and another metal
  OR
  (an alloy is) a mixture of a metal and another element; **[1 mark]**

  allow combination for mixture
  reject compound or references to chemical bonding/combining of metals

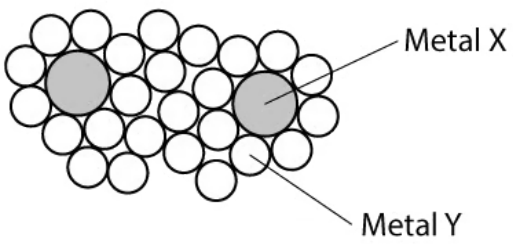
[Total: 1 mark]

(1 mark)

(d) Magnesium can be mixed with other elements to form an alloy to make it harder.

The structure of an alloy is shown in **Figure 1**.

Figure 1



Complete the sentence to explain why an alloy is harder than a pure metal:

The atoms in an alloy are different _____ so the layers are unable to _____ over each other when pressure is applied.

Answer

The completed sentence is:

The atoms in an alloy are different **sizes,** so the layers are unable to **slide** over each other when pressure is applied.

- Sizes; [1 mark]
- Slide; [1 mark]

[Total: 2 marks]

(2 marks)

(e) Why is it incorrect to describe an alloy as a compound?

Answer

An alloy is not a compound because:

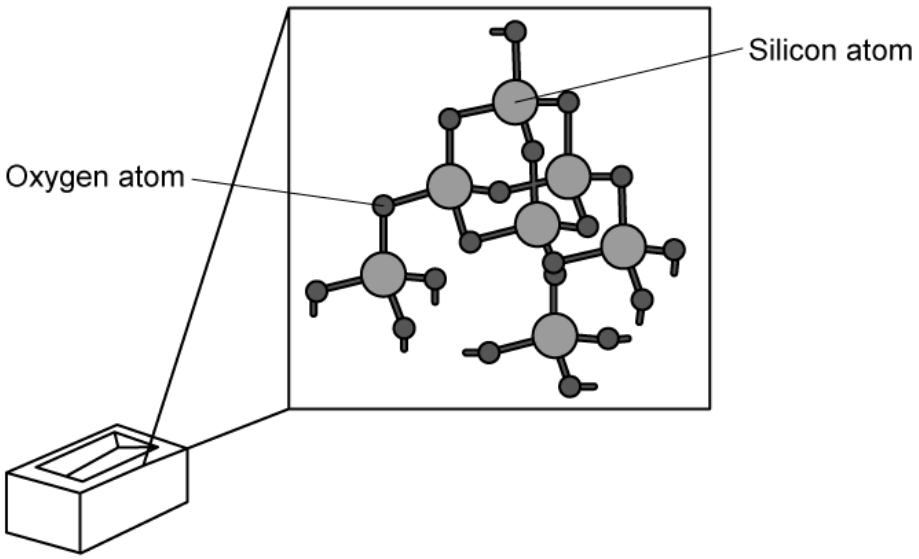
- The atoms are not chemically bonded together; [1 mark]

[Total: 1 mark]

(1 mark)

3 (a) This question is about silicon dioxide. It's structure is shown in **Figure 1**.

Figure 1



Which two elements are found in silicon dioxide?

Answer

The two elements in silicon dioxide are:

- Silicon; [1mark]
- Oxygen; [1mark]

[Total: 2 marks]

- **Remember:** The -IDE ending on the chemical name tells you that there are two elements in the compound
  - Silicon is the more obvious element to identify
  - The -IDE is part of the word OXIDE, which means that you are looking for an element linked to OX-
    - This has to be oxygen

(2 marks)

(b) Silicon dioxide is used in bricks that line furnaces which operate at high temperatures.

Use the words in the box to complete the sentences which explain why it can be used for this purpose.

high	energy	strong
low	small	six
ionic	giant	four

Silicon dioxide has a _____ structure.

Each silicon atom is joined to _____ oxygen atoms by _____ covalent bonds.

These bonds need lots of _____ to break.

Silicon dioxide therefore has a _____ melting point.

Answer

The completed sentences are:

Silicon dioxide has a **giant or covalent** structure.

Each silicon atom is joined to **four** oxygen atoms by **strong** covalent bonds.

These bonds need lots of **energy** to break.

Silicon dioxide therefore has a **high** melting point.

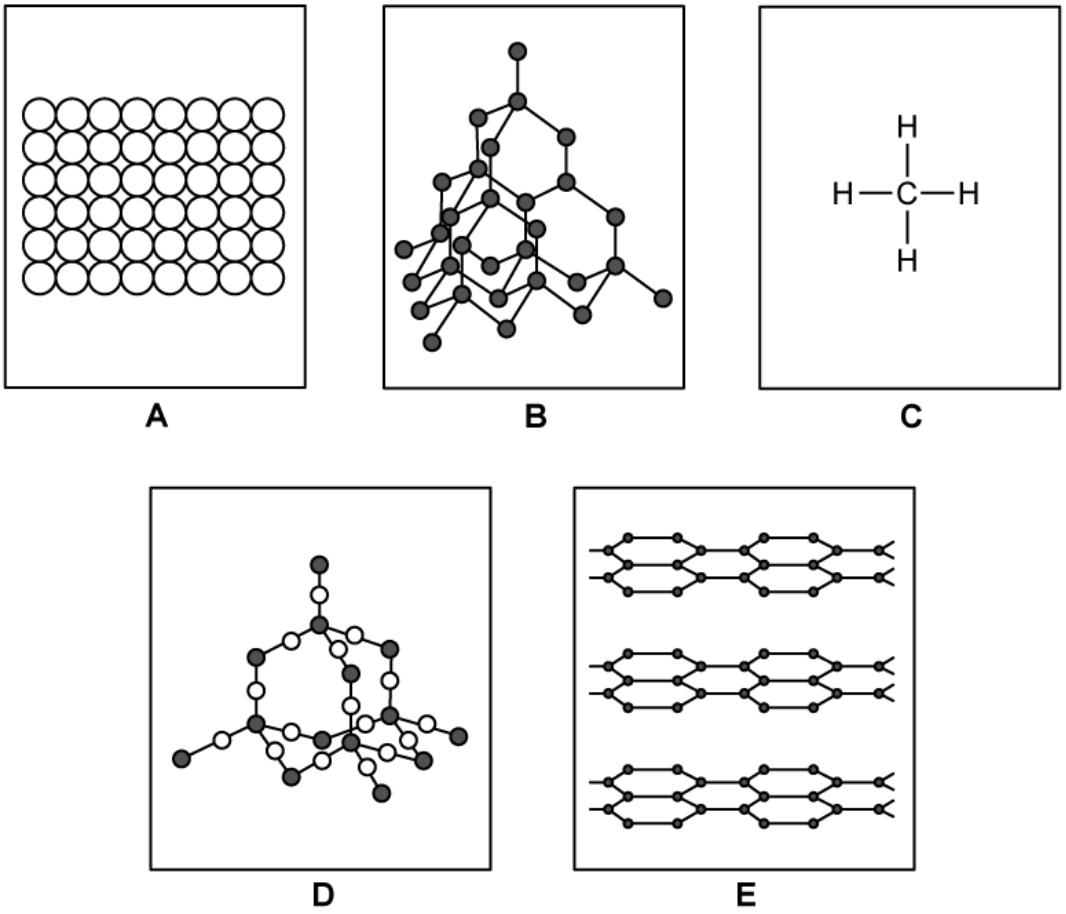
- Giant; [1 mark] *accept covalent*
- Four; [1 mark]
- Strong; [1 mark]
- Energy; [1 mark]

- High; [1 mark]

[Total: 5 marks]

(5 marks)

4 (a) The structures of five substances are represented below:



Give **one** substance, **A**, **B**, **C**, **D** or **E** that:

Is a metal	
Represents the structure of diamond	
Is soft and slippery	
Is a compound	

Answer

The correctly identified substances are:

- Is a metal: **A**; [1 mark]
- Represents the structure of diamond: **B**; [1 mark]
- Is soft and slippery: **E**; [1 mark]
- Is a compound: **C OR D**; [1 mark]

[Total: 2 marks]

- **A** is a metal as a pure metal has atoms arranged in layers
- **B** is the structure of diamond
- **E** is graphite which is soft and slippery due to having layers that can slide over each other
- A compound contains more than one element chemically joined together, **C** and **D** show structures with different elements chemically bonded
    - **C** is methane; carbon and hydrogen atoms are chemically bonded
    - **D** is silicon dioxide; silicon and oxygen atoms are chemically bonded

(4 marks)

(b) Which element are substances **B** and **E** made from?

Answer

The element is:

- Carbon; [1 mark]

[Total: 1 mark]

- **B** shows the structure of diamond and **E** is graphite
- These structures are made from carbon

(1 mark)

(c) Substance C is methane, CH_4.

Which two statements are correct about methane? Tick (✓) **two** boxes.

It has weak intermolecular forces	
It cannot conduct electricity	
It has a high melting point	
It can conduct electricity	
It has a low boiling point	

Answer

The correct statements about methane are:

- It has weak intermolecular forces; [1 mark]
- It cannot conduct electricity; [1 mark]

[Total: 2 marks]

- Methane consists of small molecules
- Even though there are strong covalent bonds between atoms, there are only weak forces between molecules
- It cannot conduct electricity as there are no freely charged particles that are able to move

(2 marks)

5 (a) This question is about calcium chloride, $CaCl_2$.

What is the total number of atoms in calcium chloride?

Answer

The total number of atoms is:

- Three; [1 mark]

[Total: 1 mark]

- There is one calcium atom
- There are two chlorine atoms

(1 mark)

(b) What type of bonding is found in calcium chloride?

Tick (✓) **one** box.

Ionic	
Covalent	
Metallic	

Answer

The type of bonding in calcium chloride is:

- Ionic; [1 mark]

[Total: 1 mark]

- Ionic bonds form between metal and non-metals

(1 mark)

(c) How many **negative** ions are there in the formula for calcium chloride?

Answer

The number of negative ions is:

- Two; [1 mark]

[Total: 1 mark]

- To form an ionic bond, the metal atoms lose electrons to form positive ions and the non-metal atoms gain electrons to form negative ions
- The formula $CaCl_2$ therefore tells us we have one positive ion and two negative ions

(1 mark)

(d) Suggest **three** properties of calcium chloride.

Answer

Some properties of calcium chloride are:

Any **three** from:

- (Is a) giant structure/lattice structure; [1 mark]
- Crystalline / hard; [1 mark]
- High melting point / solid; [1 mark]
- High boiling point; [1 mark]
- Conductor (of electricity) when dissolved in water
  OR
  Conductor (of electricity) when ions are free to move; [1 mark]
- Conductor (of electricity) when molten; [1 mark]
- Soluble in water; [1 mark]

[Total: 3 marks]

- Calcium chloride has ionic bonding
- Ionic compounds have the above properties

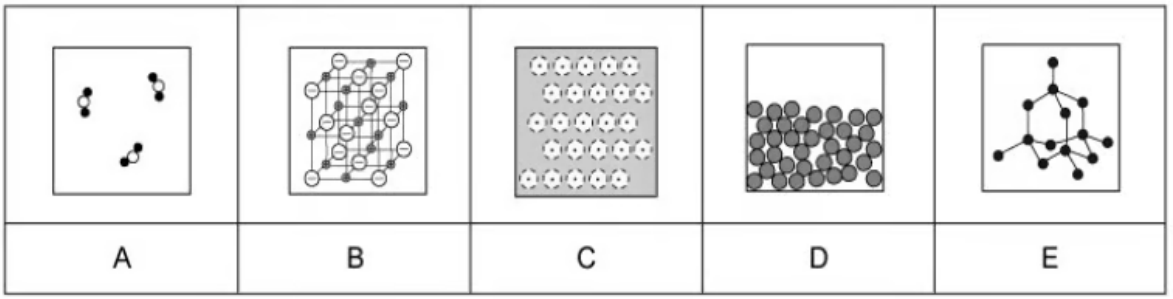
(3 marks)

Medium Questions

1 (a) This question is based on the structure of different substances.

Identify each substance in **Figure 1** by writing the letter next to the corresponding sentence.

Figure 1



This substance is a liquid: _____

This substance is a gas: _____

This substance is a metal: _____

This substance is diamond: _____

This substance is ionic: _____

Answer

The diagram shows the following:

- This substance is a liquid: D; [1 mark]
- This substance is a gas: A; [1 mark]
- This substance is a metal: C; [1 mark]
- This substance is diamond: E; [1 mark]
- This substance is ionic: B; [1 mark]

[Total: 5 marks]

(5 marks)

(b) Magnesium is a reactive metal that combusts in air to form magnesium oxide.

Balance the equation for the reaction below and give the meaning of the state symbols (s) and (g).

$$\_\_ Mg\ (s) + \_\_O_2\ (g) \rightarrow \_\_MgO\ (s)$$

Answer

The balanced equation is:

- **2**Mg (s) + O_2 (g) → **2**MgO (s);[1 mark]
- (s) = solid; [1 mark]
- (g) = gas or gaseous; [1 mark]

[Total: 3 marks]

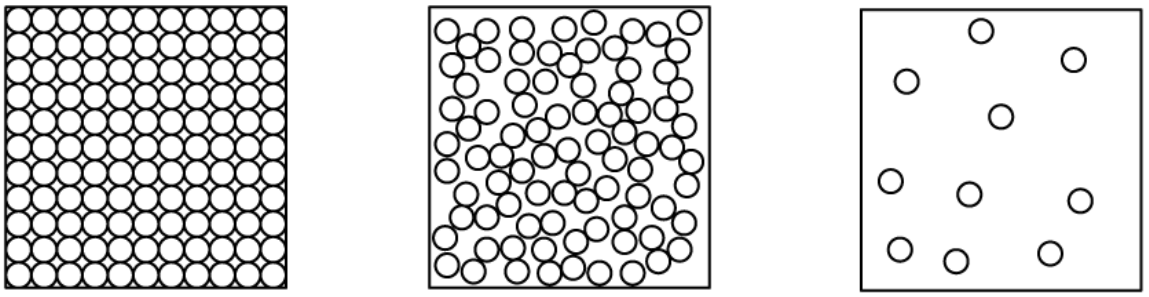
- State symbols indicate the state of a substance at room temperature.
- There is also (l) liquid, and (aq) aqueous, which means dissolved in water.

(3 marks)

(c) Higher:

The following particle diagrams in **Figure 2** are routinely used to represent the three phases of matter:

Figure 2



State **three** limitations of these models.

Answer

Three limitations are:

- The models do not account for forces of attraction between the particles; [1 mark]
- It considers all particles as spherical in shape; [1 mark]
- It does not consider the size of the particles; [1 mark]

[Total: 3 marks]

(3 marks)

2 (a) A student was investigating a calcium salt labelled **Y.**

The student found that **Y:**

- has a very high melting point
- does not conduct electricity
- is water soluble and the solution produced conducts electricity

What type of bonding is present in salt **Y**?

Answer

The type of bonding is:

- Ionic bonding; [1 mark]

[Total: 1 mark]

- Ionic compounds cannot conduct electricity when solid as the ions cannot move, whereas in solution or molten the ions are free to move and carry a charge.
- They also have high melting points due to strong electrostatic attraction between oppositely charged ions that needs lots of energy to break.

(1 mark)

(b) Explain why the solid **Y** does **not** conduct electricity but its aqueous solution does.

Answer

It's electrical conductivity can be explained by:

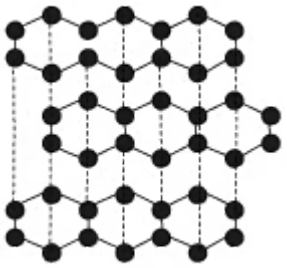
- Solid ions are in fixed positions and unable to carry a charge; [1 mark]
- Ions in an aqueous solution can move and carry a charge; [1 mark]

[Total: 2 marks]

(2 marks)

(c) **Figure 1** shows the bonding arrangement of an element.

Figure 1



What is the element?

Tick (✔) **one** box.

Element	
Chromium	
Carbon	
Silicon	
Graphite	

Answer

The element is:

- Carbon; [1 mark]

[Total: 1 mark]

- Figure 1 shows graphite, and graphite consists of carbon atoms

(1 mark)

(d) The image in **Figure 1** is an allotrope.

Why does this allotrope conduct electricity?

Answer

It can conduct electricity because:

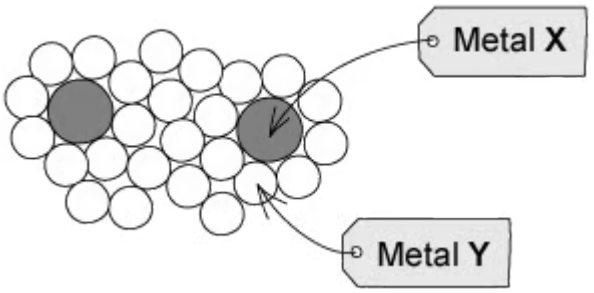
- It has delocalised electrons; [1 mark]
- They are free to move and carry a charge; [1 mark]
- Through the structure; [1 mark]

[Total: 3 marks]

(3 marks)

(e) **Figure 2** shows the particle diagram of an alloy.

Figure 2



Explain why this alloy is harder than pure metal Y.

Answer

Alloys are harder because:

- The atoms/ ions/ particles are different sizes; [1 mark]
- The layers are unable to slide over each other; [1 mark]

[Total: 2 marks]

- **Remember:** make sure you say atoms, ions or particles, not molecules.

(2 marks)

(f) What kind of substances are alloys?

Tick (✔) **one** box.

Elements	
Mixtures	
Compounds	

Answer

Alloys are:

- Mixtures; [1 mark]

[Total: 1 mark]

- An alloy is a mixture of metals (and can sometimes contain non-metals, such as carbon)

(1 mark)

3 Different substances have characteristic melting and boiling points, depending on the strength of the bonds or forces holding them together.

Which explains why methane has a lower melting point than sodium chloride?

A. Covalent bonds are weaker than ionic bonds

B. Intermolecular forces are weaker than ionic bonds

C. Covalent bonds are stronger than ionic bonds

D. Intermolecular forces are stronger than ionic bonds

Answer

The correct answer is B because:

- Methane is a simple covalent molecule
- When methane melts the relatively weak intermolecular forces between the molecules are broken
- The strong covalent bonds within the molecule remain unbroken

(1 mark)

4 Element X has the following properties:

- melts at 450^{o}C
- boils at 1091^{o}C
- Forms an ion with a 2+ charge

Which is most likely to be element X?

A. Sodium

B. Magnesium

C. Carbon

D. Oxygen

Answer

The correct answer is B because:

- Magnesium is a metal with metallic bonding in giant metallic structure
- There are strong electrostatic attractions between the layers of metal atoms and the delocalised electrons, so the melting point and boiling point are both relatively high as a lot of energy is required to break the forces
- Magnesium is a Group 2 metal and so loses two electrons to form Mg^{2+} ions which have a 2+ charge

A is incorrect as sodium is a metal, but is in Group 1 so loses one electron per atom to form ions with a 1+ charge

C is incorrect as carbon has different giant structures with high melting points but does not form stable ions

D is incorrect as oxygen is a gas and the atoms can gain two electrons to form ions with a 2- charge

(1 mark)

5 (a) Marble slabs for kitchen countertops are cut from huge blocks of marble which are extracted from quarries. The extraction process involves cutting the marble blocks with a metal cable connected to a rotary motor. Water is sprayed onto the marble for cooling.

The cable used is made from a steel alloy.

Suggest **two** advantages of using an alloy instead of a pure metal for this process.

Answer

Alloys are used instead of pure metals because:

Any **two** for one mark each:

- Alloys are harder and tougher due to the distortion of the layers of atoms in the metal structure; [1 mark]
- They have higher melting points; [1 mark]
- Alloys are more resistant than pure metals; [1 mark]
- So the cable will last longer / less costly; [1 mark]

[Total: 2 marks]

(2 marks)

(b) For particularly dense marble, or marble which contains grains of other rock types, the cutting cable is encrusted with diamond dust.

Suggest a reason why.

Answer

Diamond is used in cutting tools because:

- Diamond is an extremely hard substance; [1 mark]

[Total: 1 mark]

- Diamond is hard as each carbon atom is covalently bonded to four other carbon atoms

(1 mark)

(c) Diamond has a very high melting points.

Explain why in terms of the bonding arrangement.

Answer

Diamond has a high melting point because:

- It has a giant structure; [1 mark]
- It has covalent bonding between atoms; [1 mark]
- These covalent bonds are very strong; [1 mark]
- The bonds need lots of energy to overcome them; [1 mark]

[Total: 4 marks]

- **Tip:** When answering questions on melting / boiling points, always structure your answer in the following way:
  - Does it have a giant structure or consist of small molecules?
  - What kind of bonds / forces are between the particles that need to be broken?
  - Are they strong or weak bonds / forces?
  - Refer to the amount of energy required to break the bonds / forces

(4 marks)

6 (a) Explain why diamond has a higher melting and boiling point than carbon dioxide.

Answer

Diamond has a higher melting/boiling point because:

- Diamond has strong covalent bonds; [1 mark]
- Carbon dioxide has weak intermolecular forces; [1 mark]
- These need less energy to overcome than covalent bonds; [1 mark]

[Total: 3 marks]

- Carbon dioxide also has covalent bonds between the atoms, but it is the weak intermolecular forces that are overcome at its melting / boiling point, not the covalent bonds.
- In diamond, the covalent bonds are being broken.

(3 marks)

(b) Metals are good conductors of electricity.

Explain why.

Answer

Metals are good electrical conductors because:

- They / metals contain delocalised electrons; [1 mark]
- These electrons are free to move and carry a charge; [1 mark]
- Through the structure; [1 mark]

[Total: 3 marks]

(3 marks)

7 Sodium chloride is often known as 'table salt'.

Which compound represents sodium chloride?

	Conducts electricity when solid	Conducts electricity when molten	State at room temperature and pressure	Can be bent or shaped
A	Yes	Yes	Solid	Yes
B	No	No	Solid	No
C	No	Yes	Solid	No
D	No	No	Solid	Yes

Answer

The correct answer is C because:

- Sodium chloride is an ionic compound
- When it is solid, the ions are in fixed positions in the giant ionic lattice structure, and cannot move in order to carry a charge.
- This means that solid sodium chloride does not conduct electricity
- When it is molten, the ions are able to move freely and can carry a charge.
- This means that molten sodium chloride can conduct electricity
- It forms a giant ionic structure which is held together as a lattice with strong electrostatic forces of attraction between the oppositely charged ions. It is therefore solid at room temperature and is brittle, so cannot be bent or shaped

A is incorrect as it represents a metal, which can conduct when molten or solid, and can be bent and shaped

B is incorrect as it represents diamond, which cannot conduct electricity or be bent into shape

D is incorrect as it represents a polymer, which cannot conduct electricity but can be bent and shaped

(1 mark)

8 Limewater is the common name for calcium hydroxide solution, $Ca(OH)_2$ (aq). It is commonly used as a test for carbon dioxide, whereupon the following reaction occurs:

$$\mathbf{Ca(OH)_2\ (aq) + CO_2\ (g) \rightarrow CaCO_3\ (s) + H_2O\ (l)}$$

Which of the following statements is **not** true about the reaction?

A. Calcium hydroxide is dissolved in water

B. One product is a gas

C. The solution will turn cloudy

D. The solution will become increasingly dilute during the reaction

Answer

The correct answer is B because:

- The only gas present is carbon dioxide, identified by (g) and which is a reactant not a product

A is incorrect as the symbol (aq) does show that a substance is dissolved in water

C is incorrect as the symbol (s) does show that a solid will form and so the solution would get cloudy

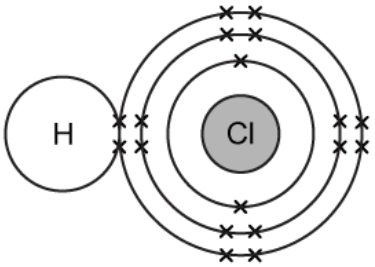
D is incorrect as water is formed as calcium hydroxide is used up, so the resulting solution will be more dilute

(1 mark)

9 (a) The hydrogen halides (HF, HC*l*, HBr and HI) are compounds used to produce acids.

Figure 1 represents a molecule of hydrogen chloride.

Figure 1



What do the crosses (**X**) represent?

Answer

The crosses are:

- Electrons; [1 mark]

[Total: 1 mark]

- Electrons are located in shells that surround the nucleus
- Protons and neutrons are located inside the nucleus

(1 mark)

(b) What type of bonding is present in this molecule?

Answer

The type of bonding is:

- Covalent; [1 mark]

[Total: 1 mark]

- Hydrogen and chlorine are both non-metals
- Covalent bonding occurs between non-metal atoms

(1 mark)

(c) Predict whether hydrogen chloride is a solid, liquid or gas at room temperature and pressure.

Explain your answer.

Answer

The substance could be:

- A gas or a liquid [1 mark]

Any **two** further points from:

- It consists of small molecules; [1 mark]
- It has a low boiling point; [1 mark]
- The forces acting between the molecules are weak; [1 mark]
- Little energy is needed to overcome the weak intermolecular forces; [1 mark]

[Total: 3 marks]

(3 marks)

10 (a) This question is based on the chemistry of polymers.

Polyvinyl chloride (PVC) is a commonly used polymer.

State the term used to describe the units from which polymers are made and name the type of bonding between these units.

Answer

The terms for the units from which polymers are made and the type of bonding between these units are:

- Monomers; [1 mark]
- They have covalent bonds; [1 mark]

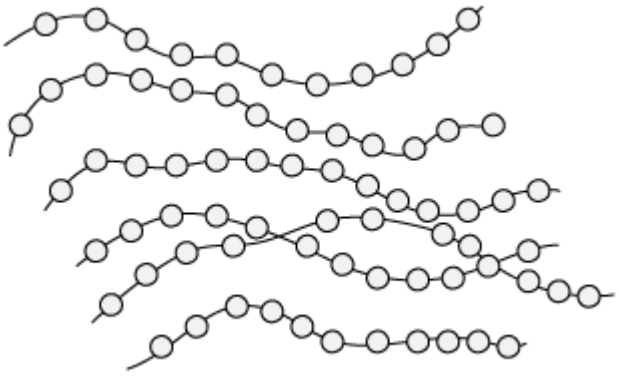
[Total: 2 marks]

- Polymers consist of non-metal atoms
- Covalent bonds are found between non-metal atoms

(2 marks)

(b) **Figure 1** represents short chains of PVC.

Figure 1



Although hard material is used in water pipes and drains, PVC softens and melts when heated.

Use the diagram and your knowledge of structure and bonding to explain why this occurs.

Answer

PVC melts when heated because:

Any **three** from:

- There are intermolecular forces **or** forces between the chains; [1 mark]
- These intermolecular forces are weak; [1 mark]
- And are easily overcome by heat as only a little energy is needed; [1 mark]
- The chains or molecules can slide over one another when the forces have been overcome; [1 mark]

[Total: 3 marks]

- Don't confuse intermolecular forces with chemical bonds.
- These forces are weak and act in-between molecules while bonding occurs between atoms and are much stronger.

(3 marks)

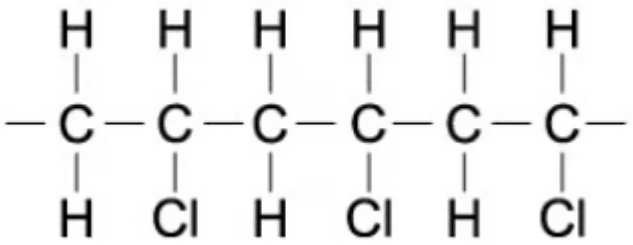
(c) The basic unit of polyvinyl chloride is C_2H_3Cl.

The polymer chain consists of many of these base units bonded together.

In the space provided, draw a section of a chain of PVC showing three units joined together.

Answer

A section of a chain of PVC showing three units joined together looks like:



- 6 carbon atom chain; [1 mark]
- Alternating H and Cl on one side chain; [1 mark]
- Single bonds only; [1 mark]

[Total: 3 marks]

- The monomer will have double bonds
- This double bond breaks when the monomers join together to give a saturated polymer (one with single bonds only)

(3 marks)

Hard Questions

1 (a) This question is about the bonding in different substances.

Table 1 shows some information about substances **A - E.**

Table 1

Substance	Melting point in ^{o}C	Boiling point in ^{o}C	Does it conduct electricity when solid?	Does it conduct electricity when dissolved or molten?
A	-208	-200	No	No
B	-220	-180	No	No
C	802	1415	No	Yes
D	115	450	No	No
E	1080	2563	Yes	Yes

Use **Table 1** to answer the following questions.

Give the state symbol of substance **B** at -202 ^{o}C.

Answer

The state symbol for Substance **B** is:

- (l) / liquid; [1 mark]
  Accept without brackets

[Total: 1 mark]

- The melting point is −220 °C, the temperature at which the substance goes from a liquid to a solid
- The boiling point is −180 °C the temperature at which the substance goes from a liquid to gas
- −202 °C is above −220 °C but below −180 °C. so the substance is a liquid, and the state symbol (l)
- State symbols are used in equations to indicate the physical state that a substance is in
    - They can be (s) = solid, (l) = liquid, (g) = gas or (aq) = aqueous

(1 mark)

(b) Substance **E** can conduct electricity when solid and molten.

Explain why.

Answer

Substance **E** can conduct electricity when molten and solid because:

- It is a metal / has metallic bonding; [1 mark]
- There are delocalised electrons; [1 mark]
- Which are free to move (through the structure) and carry a charge; [1 mark]

[Total: 3 marks]

- Metals conduct in both the solid and molten state
- By deducing that substance **E** is a metal, you know that your answer should include electrons moving, and not ions
    - This is a common mistake to make, and should only be used if the structure exhibits ionic bonding

(3 marks)

(c) One of the substances in the table is sodium chloride.

Identify which substance is sodium chloride.

Give a reason for your answer.

Answer

Sodium chloride is:

- Substance **C** ; [1 mark]
- (Because) it can conduct when molten / dissolved but not when solid; [1 mark]

[Total: 2 marks]

- Sodium chloride is an ionic substance as it consists of a metal and non-metal
- Ionic substances do not conduct electricity when solid
    - This is because their ions are in fixed positions which means that they cannot move and carry a charge
- Ionic substances can conduct electricity when they are molten or dissolved in water
    - This is because they have ions that can move and carry a charge

(2 marks)

(d) Explain why substance **A** has a relatively low boiling point.

Answer

Substance **A** has a relatively low boiling point because:

- It consists of small molecules; [1 mark] *Accept it has a simple molecular structure*
- It has weak intermolecular forces; [1 mark]
- That don't require a lot of energy to overcome; [1 mark] *Accept it is easy to overcome the forces*

[Total: 3 marks]

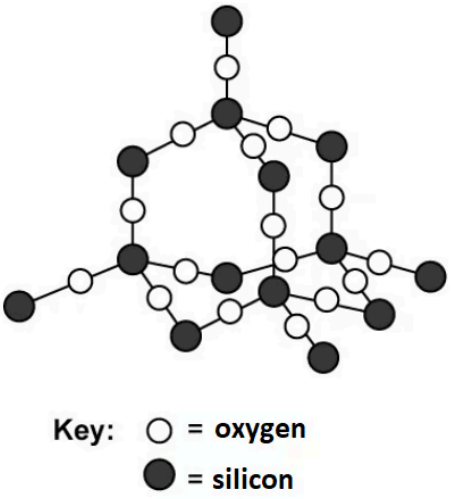
- You can deduce from the question saying it has a low boiling point that it will consist of small molecules
- Small molecules consist of just a few atoms, e.g CO_2
- Small molecules contain strong covalent bonds between the atoms, for example, CO_2 has strong covalent bonds between the carbon and oxygen atoms
- However, it is the weak forces between molecules that are broken at their boiling point
- These need much less energy to break than covalent bonds
- Substances that don't consist of small molecules have high boiling and melting points and consist of giant structures

(3 marks)

2 (a) This question is about the bonding and structure of silicon dioxide.

Figure 1 shows the structure of part of silicon dioxide.

Figure 1



Explain why silicon dioxide can be used to line furnaces.

Answer

Silicon dioxide is used to line furnaces because:

- It has a giant structure/lattice; [1 mark]
  Accept it has a macromolecular structure
  Ignore many bonds

- There are strong covalent bonds between the silicon and oxygen atoms; [1 mark]
  Accept bonds are hard to break

- Lots of energy is needed to break them ; [1 mark]

- So it has a high melting point ; [1 mark]
  Accept it will not melt at high temperatures

[Total: 4 marks]

- You know it must have a high melting point to be used in furnaces

- From there, you can deduce it has a giant structure and strong bonds which must need lots of energy to break

- You can deduce these bonds are covalent, as silicon and oxygen are both non-metals
- In previous exams, not many students gained full marks on this question because:
  - They didn't correctly link together the points above
  - They talked about carbon atoms, possibly getting confused with the structure of diamond

(4 marks)

(b) Explain why silicon dioxide cannot conduct electricity.

Answer

Silicon dioxide and diamond cannot conduct electricity because:

- There are no free electrons that are able to move; [1 mark]
- So a charge cannot be carried through the structure; [1 mark]

[Total: 2 marks]

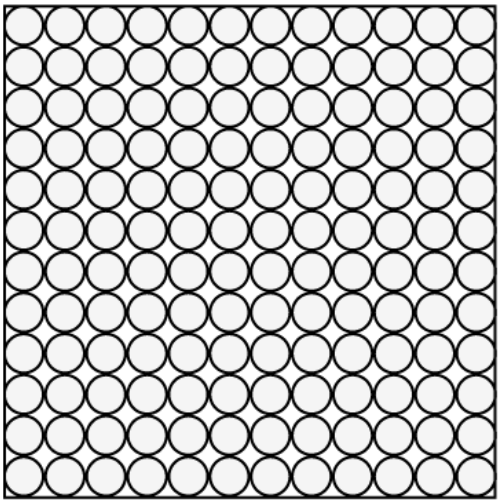
- A substance can only conduct electricity if there are freely charged particles such as electrons to move throughout the structure
- In silicon dioxide, the outer electrons form covalent bonds and are therefore unable to move

(2 marks)

(c) Silicon dioxide is a solid at room temperature.

Solids can be represented using the particle model in **Figure 2.**

Figure 2



Solid

Describe **two** limitations of this model.

Answer

Two limitations of the particle model are:

Any **two** from:

- It assumes that the particles are solid/inelastic; [1 mark]
- It assumes that the particles are spheres; [1 mark]
- It assumes that the particles are all the same size; [1 mark]
- It doesn't show the forces between the particles; [1 mark]

[Total: 2 marks]

- The particle model is really useful for explaining the differences between solids, liquids and gases but in reality, the particles that are shown are ions, atoms or molecules
- Within different substances, these could be different shapes and sizes but the particle model depicts them as equal

    - For example, In the case of silicon dioxide, the silicon atoms are larger than the oxygen atoms
- There is also no indication of the force between the particles and so it is hard to tell what the strength of these are
    - For example, silicon dioxide has strong covalent bonds
    - Even for gas there are weak forces that exist between the particles

(2 marks)

(d) Explain how, using particle theory, silicon dioxide would change state from a solid to a liquid.

Answer

To change from a solid to a liquid:

- The particles gain (kinetic) energy; [1 mark]
- (The particles) vibrate more and the forces between them break; [1 mark] *accept the bonds break*

[Total: 2 marks]

- The particles in a solid break free from their original positions but there are still weak forces of attraction between them
- The resulting liquid has particles that are able to move past each other but remain close together
- The particles need to absorb more energy in order to move faster and weaken these attractive forces even further to form a gas
- Even though you are allowed to say bonds, not all mark schemes will give you the marks for this so it is better to say forces

(2 marks)

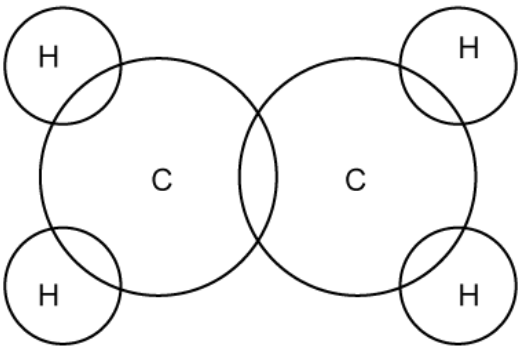
3 (a) This question is about the structure and bonding in ethene.

Ethene belongs to the homologous series of alkenes and has the formula C_2H_4.

Complete the dot and cross diagram in **Figure 1** to show the bonding of ethene.

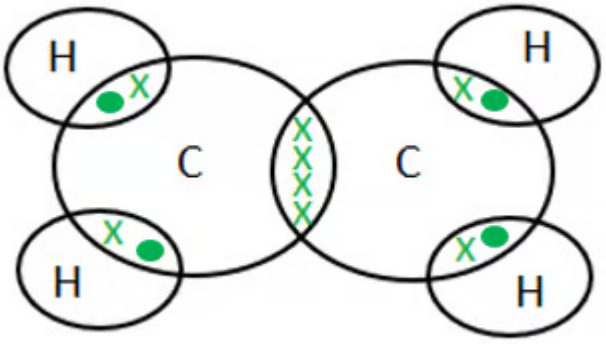
Only show the outer shell electrons.

Figure 1



Answer

The completed dot and cross diagram is:



- One pair of electrons in each overlap between carbon and hydrogen atoms (four pairs in total); [1 mark]
  Allow any combination of dots, crosses or other symbols

- Four shared electrons between the two carbon atoms; [1 mark]

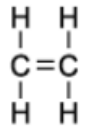
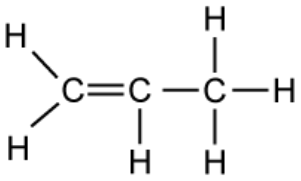
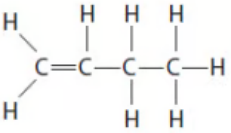
[Total: 2 marks]

- **Remember:** Only outer shell electrons are shown
- Hard examples will ask you to draw dot and cross diagrams that have more than one shared pair of electrons, e.g. carbon dioxide, oxygen and nitrogen
- Count around each atom to check you have the correct number of electrons

(2 marks)

(b) **Table 1** shows information on the boiling points and structures of ethene and two other alkenes.

Table 1

Name	Ethene	Propene	Butene
Structure			
Boiling Point in ^{o}C	-104	-47	-6.3

Use your knowledge of structure and bonding to describe and explain the trend in boiling point as the number of carbon atoms increases.

Answer

As the number of carbon atoms increases:

- The boiling point increases; [1 mark]
- (Because) The number of intermolecular forces increases; [1 mark]
  Accept the intermolecular forces get stronger

- More energy will be needed to overcome these forces [1 mark]
  Any reference to breaking covalent bonds only achieves 1 mark

[Total: 3 marks]

- Alkenes consist of small molecules
- Although there are strong covalent bonds between the carbon and hydrogen atoms, there are only weak forces between the molecules and it is these that are overcome at boiling point
- As the size of the molecule increases, the number of forces between the molecules will also increase, hence needing more energy to break

(3 marks)

(c) Ethene can undergo addition polymerisation to form the polymer poly(ethene).

Why is poly(ethene) a solid at room temperature?

Answer

Poly(ethene) is a solid at room temperature because:

- It consists of very large molecules; [1 mark]
- The intermolecular forces between the polymer molecules are strong; [1 mark]
- (They) require high amounts of energy to break them; [1 mark]

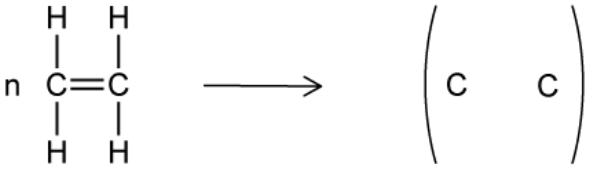
[Total: 3 marks]

- Addition polymerisation involves adding lots of ethene monomers together to form large molecules
- The intermolecular forces between polymer molecules are stronger than the ones between small molecules so they melt at higher temperatures

(3 marks)

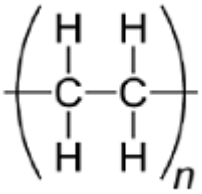
(d) Complete the structure for poly(ethene) in **Figure 2.**

Figure 2



Answer

The structure of poly(ethene) is:



- Single C–C bond and two trailing bonds with nothing attached; [1 mark]
- 4 x single C-H bonds; [1 mark]
- n at the bottom right outside of brackets; [1 mark]

[Total: 3 marks]

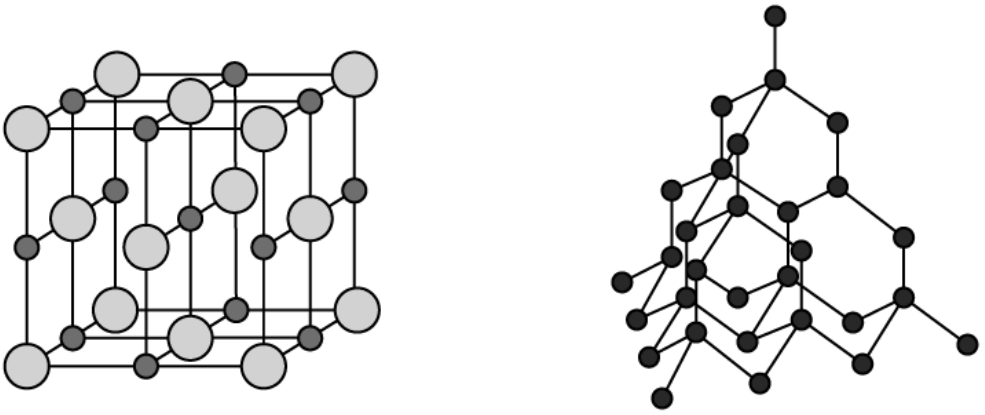
- During polymerisation, lots of the monomer (in this case ethene) join together to form one long chain
- The double bond must break to allow this to happen
- The single lines extending from the brackets indicate there are more monomers on either side and the n represents a large number
- You must be able to draw the repeating unit for any monomer that is given (this is covered more in unit 7, organic chemistry)

(3 marks)

4 (a) This question is about sodium chloride and diamond.

Figure 1 shows the structure of sodium chloride and diamond.

Figure 1



Sodium chloride has a melting point of 801 ^{o}C.

Explain why sodium chloride has a high melting point.

Answer

Sodium chloride has a high melting point because:

- It has a giant (ionic) structure/lattice; [1 mark]
- There is a strong electrostatic (force of) attraction; [1 mark]
- Between oppositely charged ions; [1 mark]
- Which needs a lot of energy to break; [1 mark]

[Total: 4 marks]

- **Tip:** For questions on melting point, follow the same structure for your answer:
  - Does it have a giant structure or consist of small molecules?
  - What type of bond/force exists?

- What does this bond/force exist between? (Oppositely charged Ions / atoms / ions and delocalised electrons?)
- Refer to the amount of energy needed to break the bonds

(4 marks)

(b) Diamond has a melting point of 4500 ^{O}C.

Explain why diamond has a higher melting point than sodium chloride.

Refer to the structure of diamond in your answer.

Answer

Diamond has a higher melting point than sodium chloride because:

- Diamond has covalent bonds between atoms; [1 mark]
- These are stronger than the forces within sodium chloride; [1 mark]

[Total: 2 marks]

- The question clearly states you need to refer to the bonding in diamond
- Diamond consists of carbon atoms so it has covalent bonds
- Your answer must give a comparison, it is not enough to simply state these covalent bonds are strong, as the electrostatic attraction between ions in sodium chloride is also strong
  - You must indicate they are **stronger** as this is the reason it has a **higher** melting point and not just high

(2 marks)

(c) Compare the electrical conductivity of sodium chloride and diamond.

Explain your answer.

Answer

The electrical conductivity of sodium and chloride and diamond is:

- Neither of them conducts electricity when they are solid; [1 mark]
- (Because) there are no freely charged particles; [1 mark] *Accept there are no free / delocalised electrons in diamond Accept ions cannot move in solid sodium chloride*
- Sodium chloride will conduct when molten or in solution; [1 mark]
- (Because) ions can move and carry a charge; [1 mark]

[Total: 4 marks]

- Make sure you are specific about whether electrons or ions can move when referring to sodium chloride
- It has **ionic** bonding so **ions** are moving

(4 marks)

5 (a) This question is about metals and alloys.

Stainless steel is an alloy of iron, chromium and nickel.

Iron is a typical metal.

Explain why it has a high melting point.

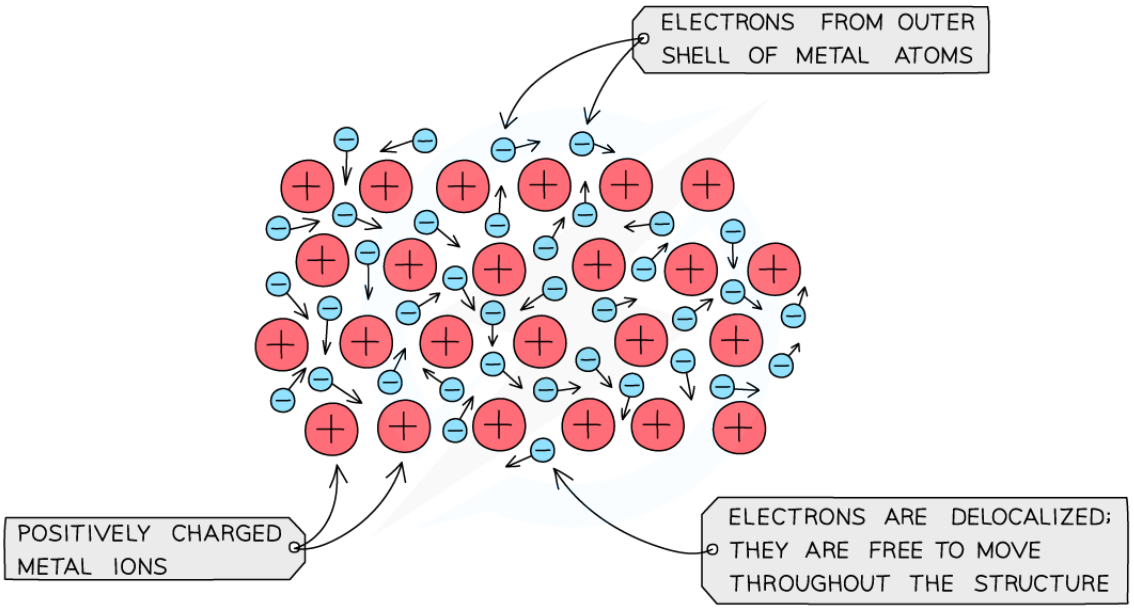
Answer

Iron has a high melting point because:

- It has a giant structure; [1 mark]
- (There are) strong forces of attraction; [1 mark]
- Between positive metal ions and delocalised electrons; [1 mark]
- Which needs lots of energy to break; [1 mark]

[Total: 4 marks]

- The structure of a metal is:



- The metallic bond is a very strong attraction between the positive metal ion and negative electrons
- This is a very strong attraction which would require large amounts of energy to overcome

(4 marks)

(b) Explain why stainless steel is harder than the iron it is made from.

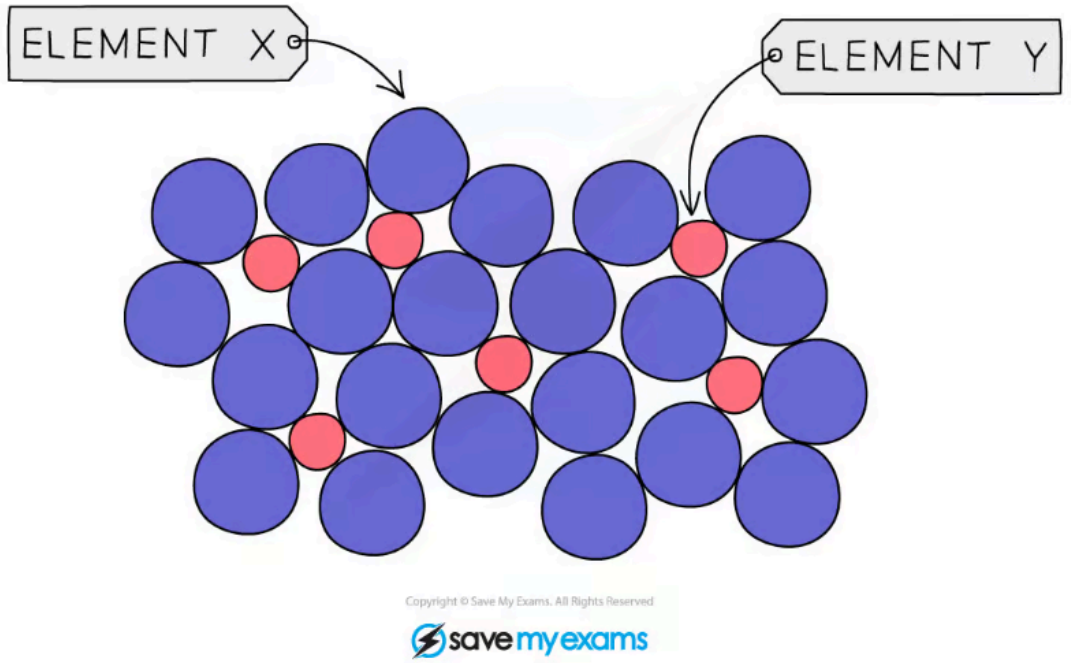
Answer

Stainless steel is harder than pure iron because:

- Atoms / ions / particles in alloy are different (sizes); [1 mark] *Do **not** allow reference to molecules*
- The layers are distorted; [1 mark]
- (So) the layers/atoms/particles do not slide over each other; [1 mark]
  Accept points made on an appropriate diagram

[Total: 3 marks]

- An alloy is a mixture of metals and can be represented as:



- Pure metals consist of the same atoms which are therefore the same size allowing layers to form
- These layers can easily slide over each other when pressure is applied
- A lot of metals are turned into alloys because the alloy is harder and therefore more useful in many materials

(3 marks)

(c) Early hip replacement joints were made from stainless steel.

Apart from being harder, suggest **one** other property of stainless steel that made them useful as hip replacement joints.

Answer

Properties of stainless steel that make them useful as hip replacement joints are:

Any **one** from:

- Resistant to corrosion; [1 mark]
- High tensile strength; [1 mark]
- It's durable; [1 mark]

[Total: 1 mark]

(1 mark)

(d) Explain why nickel and chromium are both good thermal conductors.

Answer

Nickel and chromium are both good thermal conductors because:

- Delocalised electrons are free to move (and carry thermal energy); [1 mark]

[Total: 1 mark]

- As a metal is heated, the positive ions gain kinetic energy and vibrate more
- The delocalised electrons transfer the kinetic energy to cooler parts of the metal by colliding with ions as they move

(1 mark)