14–16 years

Metallic bonding and the structure of iron

ROYAL SOCIETY OF CHEMISTRY

Education
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https://rsc.li/3botPEO

Learning objectives

1. Describe the bonding in iron.
2. Explain the properties of iron using ideas about bonding.

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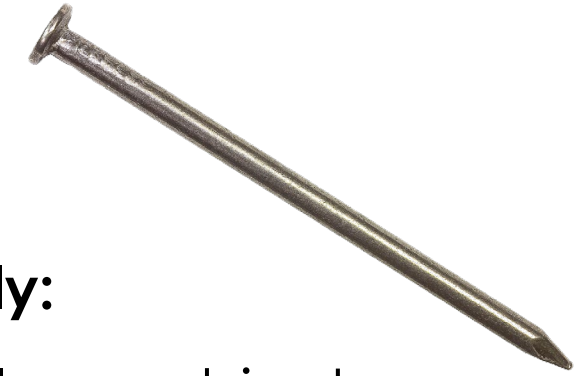
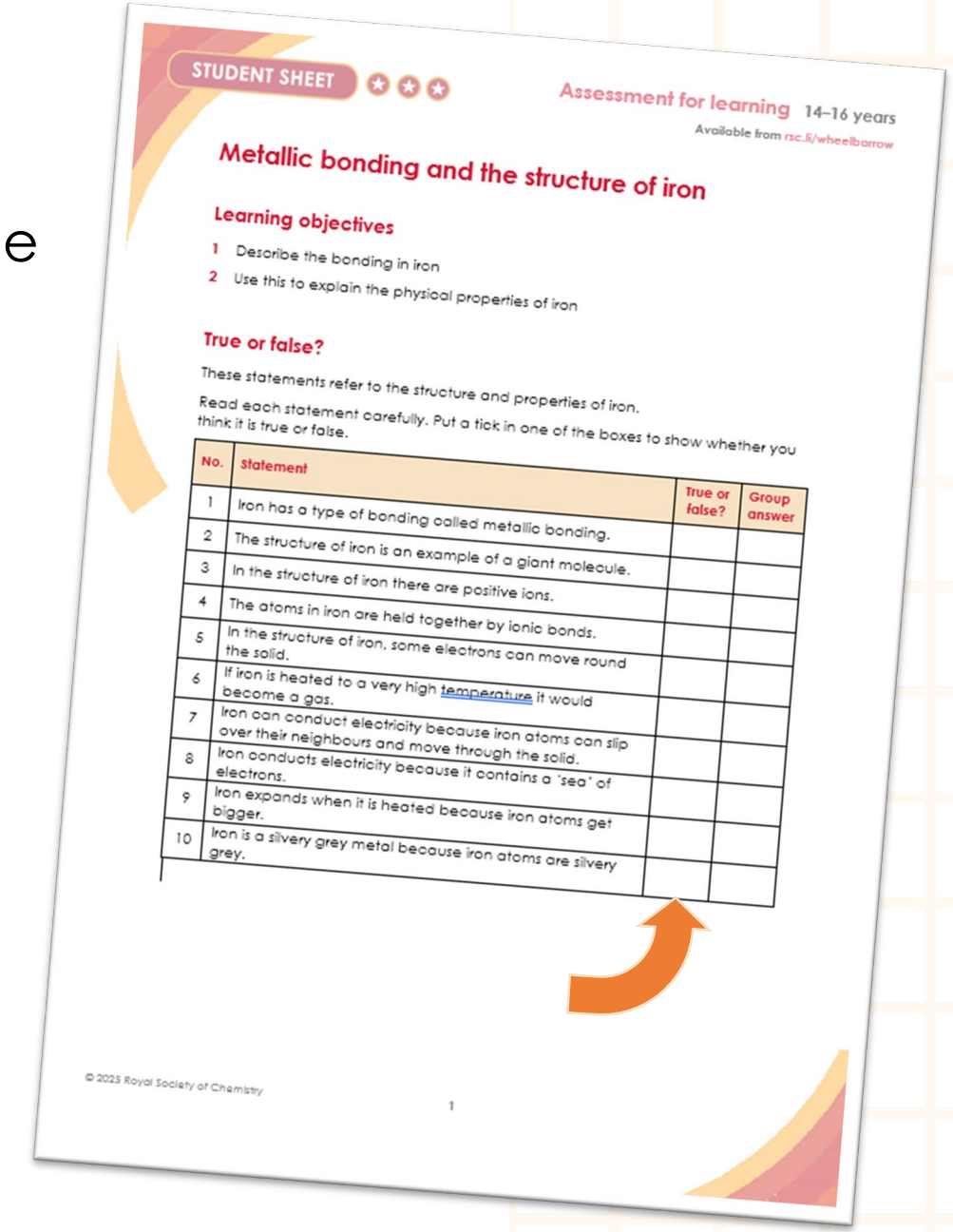
The bonding in iron

You will be given an object which is made from **iron**.



Working **individually:**

- Look at and feel your object.
- Read each statement carefully.
- Write down in the table whether you think it is **true** or **false.**



STUDENT SHEET

Assessment for learning 14–16 years

Available from rsc.li/wheelbarrow

Metallic bonding and the structure of iron

Learning objectives

1 Describe the bonding in iron

2 Use this to explain the physical properties of iron

True or false?

These statements refer to the structure and properties of iron.

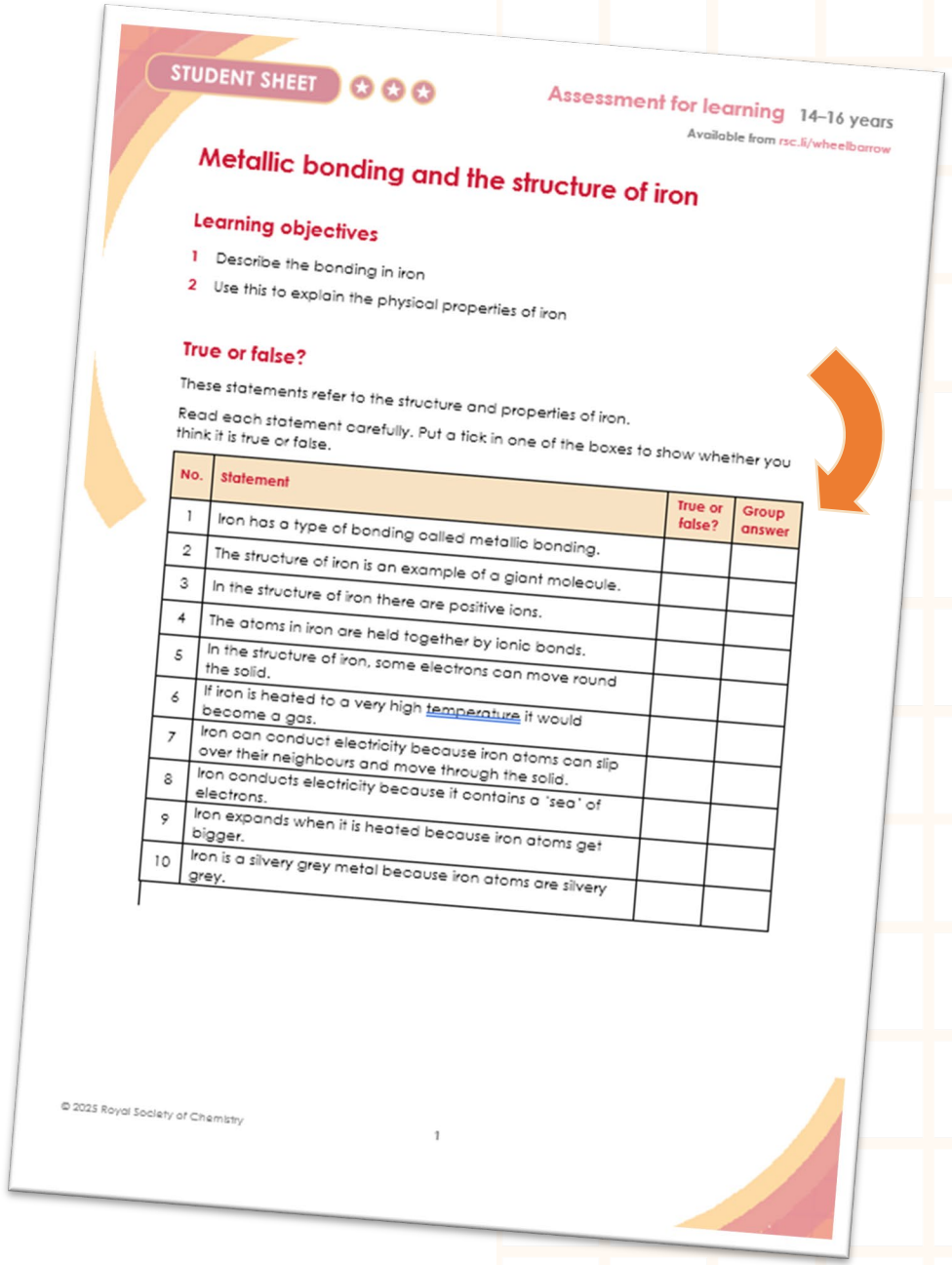
Read each statement carefully. Put a tick in one of the boxes to show whether you think it is true or false.

No.	Statement	True or false?	Group answer
1	Iron has a type of bonding called metallic bonding.		
2	The structure of iron is an example of a giant molecule.		
3	In the structure of iron there are positive ions.		
4	The atoms in iron are held together by ionic bonds.		
5	In the structure of iron, some electrons can move round the solid.		
6	If iron is heated to a very high temperature it would become a gas.		
7	Iron can conduct electricity because iron atoms can slip over their neighbours and move through the solid.		
8	Iron conducts electricity because it contains a 'sea' of electrons.		
9	Iron expands when it is heated because iron atoms get bigger.		
10	Iron is a silvery grey metal because iron atoms are silvery grey.		

Activity stage 1

Now, in groups of 3:

1. Look at each question in turn.
2. Discuss the answers you gave, and your ideas.
3. Decide on a **group answer** and record this on the table.
4. Be ready to share your ideas and how they might have changed!



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Bonding in iron

On your mini whiteboard, draw a picture to represent the bonding in iron.

Be ready to share your ideas!

Source: © Shutterstock/Frangofoto

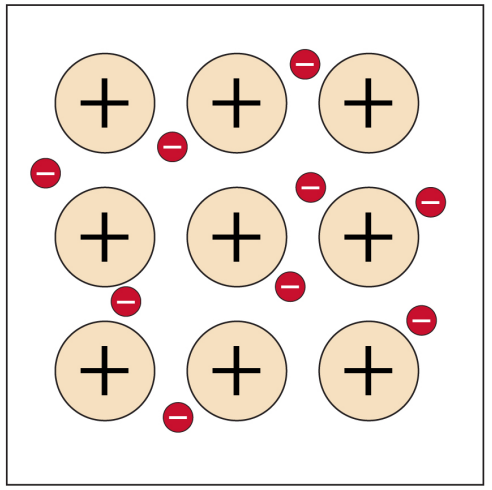
Activity stage 3

The structure of metals

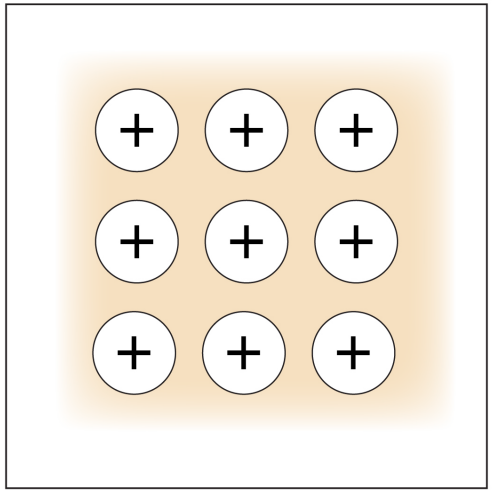
Does your diagram look like one of these two models?

Key features:

- The outer shell electrons become delocalised and are free to move through the giant lattice of positive ions.
- The electrons are sometimes shown as a ‘cloud’ and referred to as a ‘sea of delocalised electrons’ (model B).
- These models can explain the physical properties of metals: conduct electricity and heat, expand on heating, malleable and ductile.



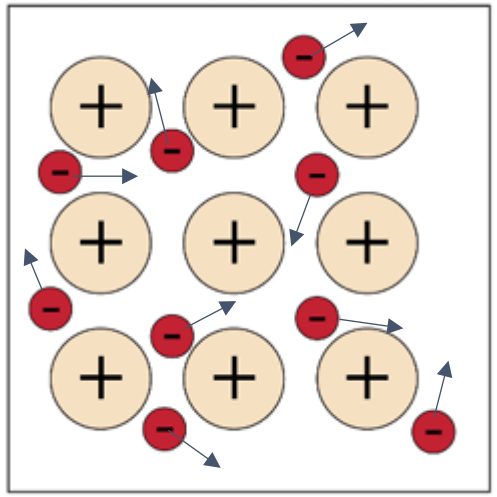
Model A



Model B

Activity stage 3

Conduction of electricity and heat



Metallic bonding is the force of attraction between positive metal ions and a sea of negative delocalised electrons.

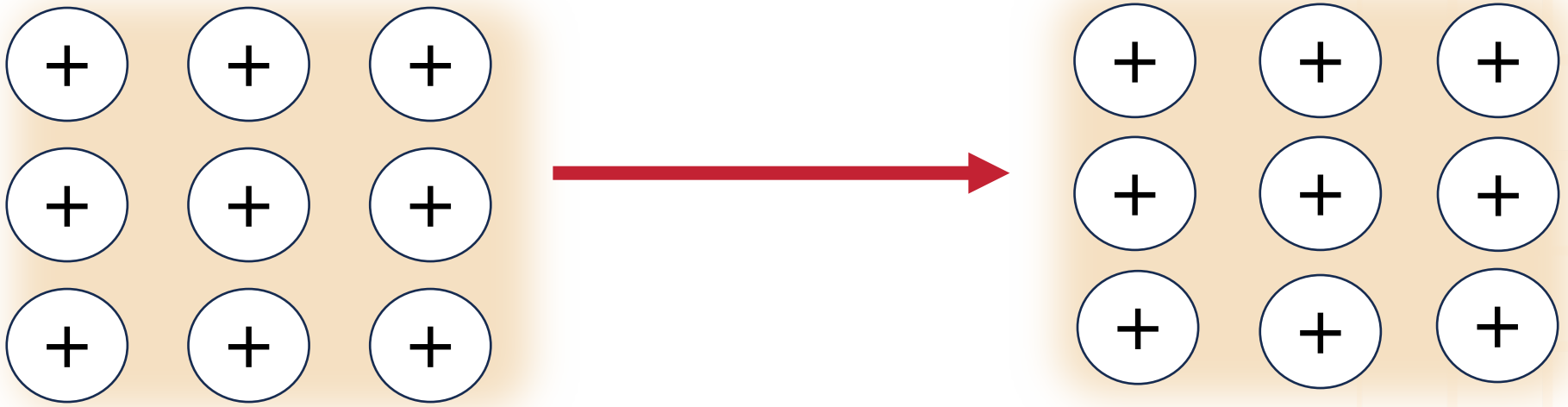
Delocalised electrons are free to move. This movement can transfer energy quickly throughout a metal making metals good conductors of heat.

Watch this short animation by Franklychemistry which illustrates why metals can conduct an electric current. https://youtu.be/wP-ELN5nC74

Expansion on heating

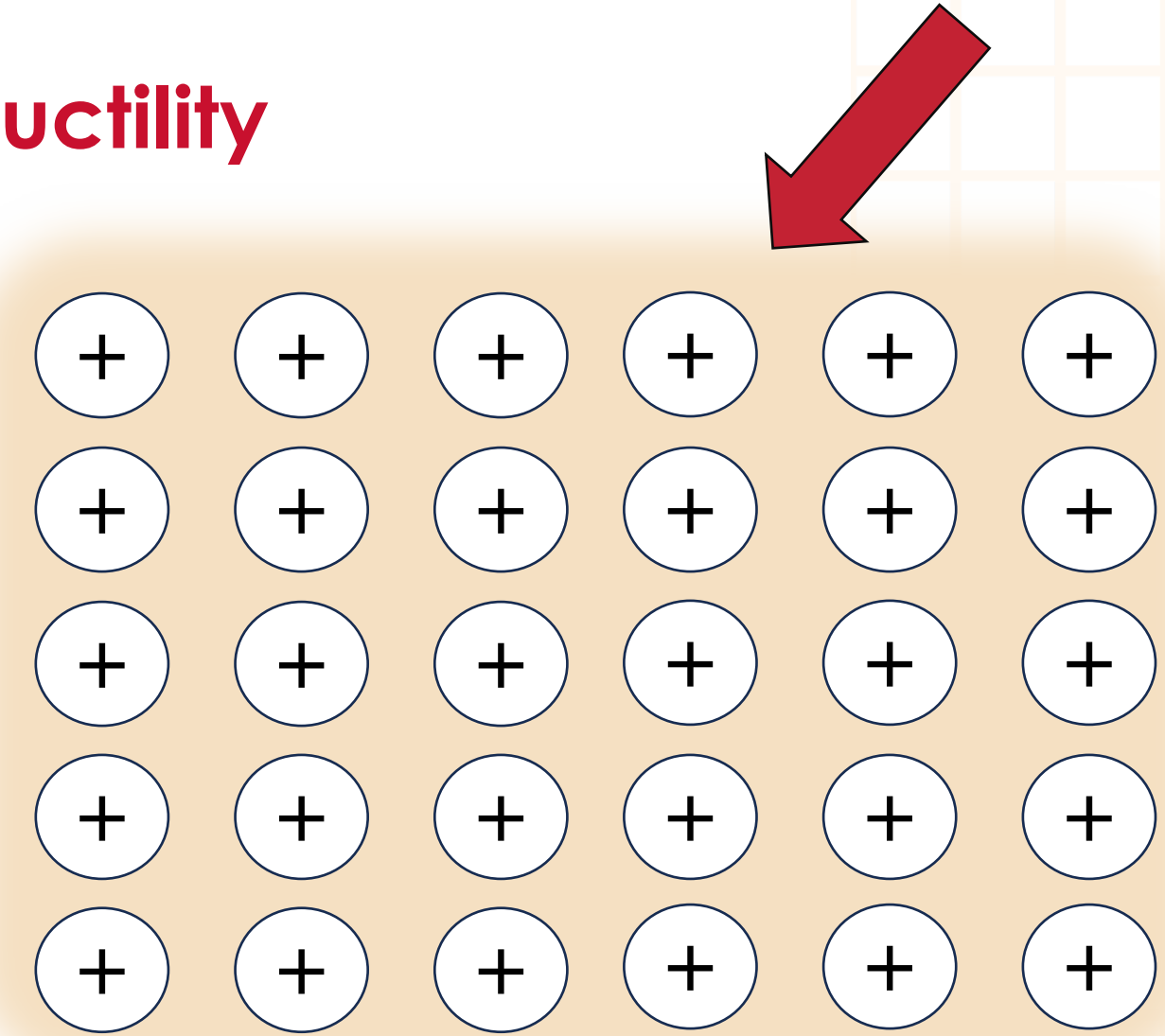
At lower temperatures, particles vibrate less.

At higher temperatures, particles vibrate more vigorously, and their volume expands.



Malleability and ductility

When a force is applied, **layers** of metal ions can slide over one another.



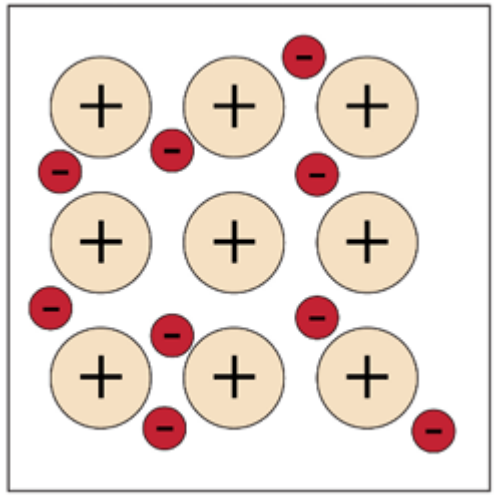
Answers

1. Iron has a type of bonding called metallic bonding.

TRUE

Iron is a **metal** and all metals have a type of bonding called **metallic bonding**, which is different from covalent or ionic bonding.

In metallic bonding, the outer shells of adjacent atoms overlap and the outer shell electrons are free to move through the lattice. The metal consists of metal cations and a balancing number of these 'free' electrons.

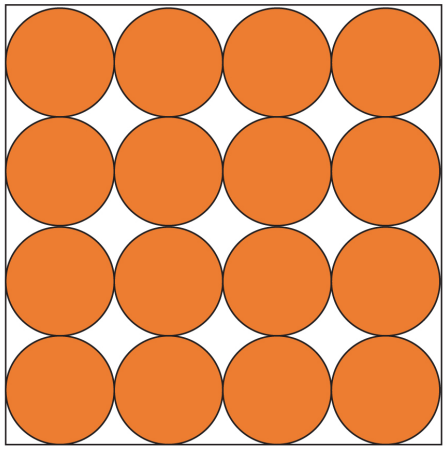


Answers

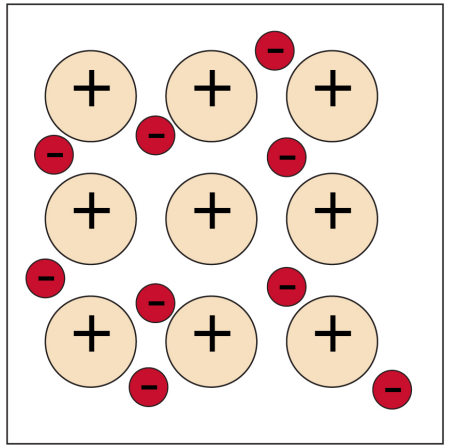
2. The structure of iron is an example of a giant molecule.

FALSE

In iron the positive ions are packed together in a **giant lattice,** but we use the word **molecule** to imply that the structure contains covalent bonds, which iron does not.



metallic structure model



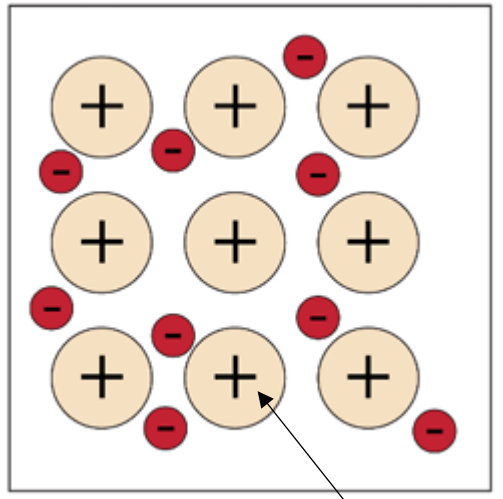
metallic bonding model

Answers

3. In the structure of iron there are positive ions.

TRUE

Because the **electrons** in the outer shell are **free to move** through the lattice, they leave behind **positive iron ions**.

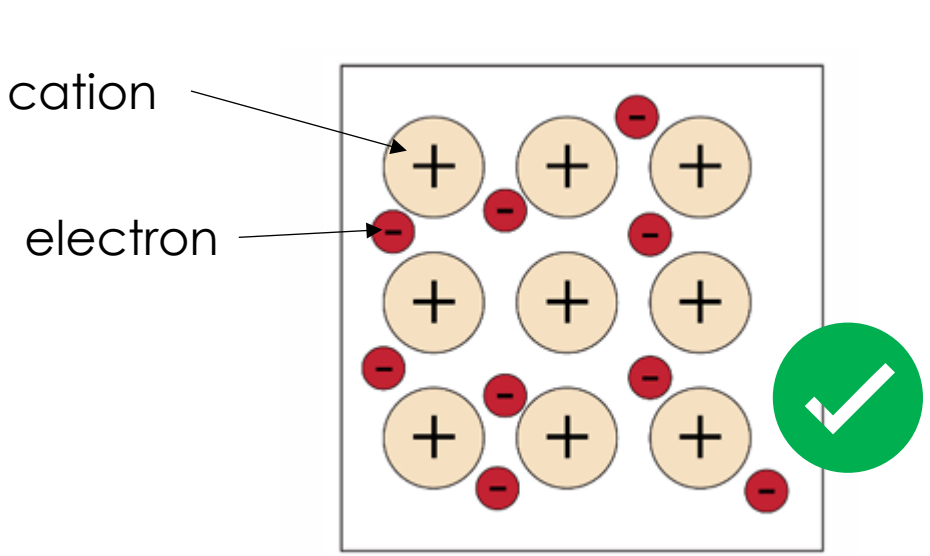


Answers

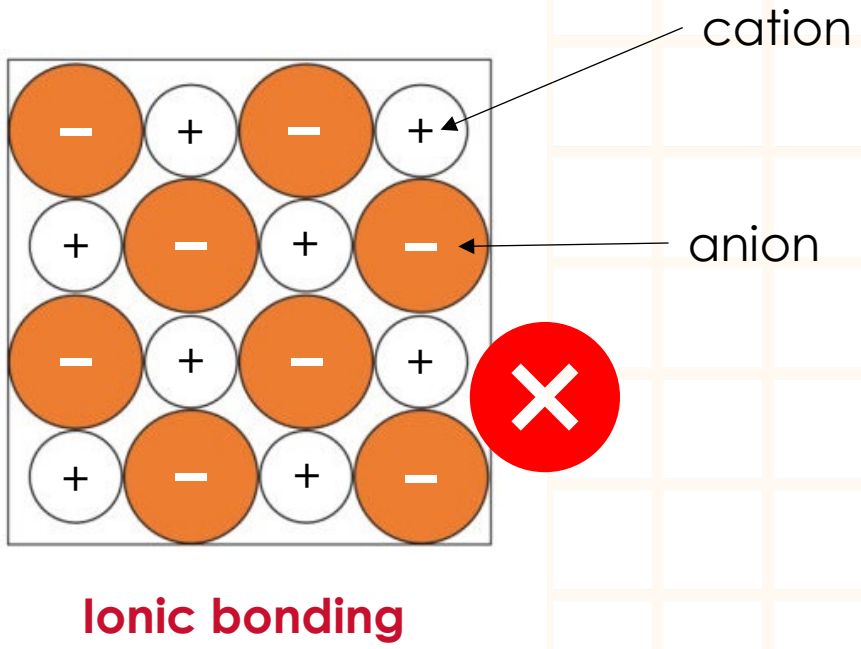
4. The atoms in iron are held together by ionic bonds.

FALSE

The bonding in iron is **metallic bonding**. This is different from ionic bonding because there are **no negative anions** present.



Metallic bonding



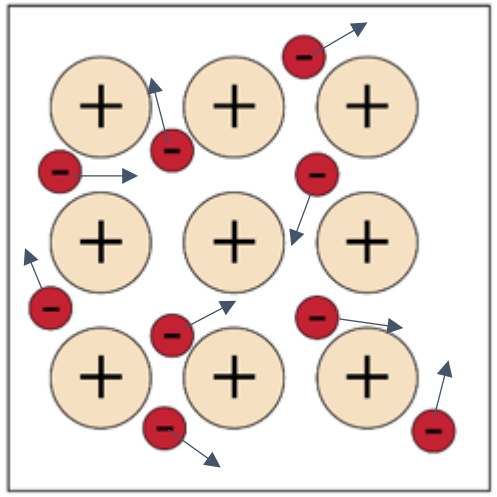
Ionic bonding

Answers

5. In the structure of iron, some electrons can move round the solid.

TRUE

The electrons from the outer shell of atoms are **free to move** through the lattice of positive ions.



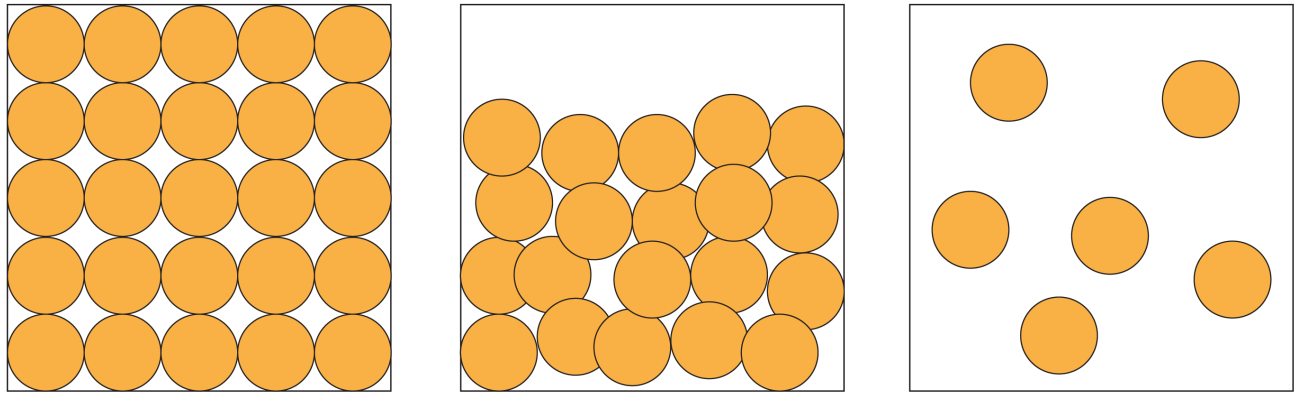
Watch this short animation by *FranklyChemistry* which illustrates why metals are able to conduct an electric current: https://youtu.be/wP-ELN5nC74

Answers

6. If iron is heated to a very high temperature, it will become a gas.

TRUE

If iron is heated it will melt. If **molten iron** is heated to a sufficiently high temperature it will **boil**.



solid iron

molten iron

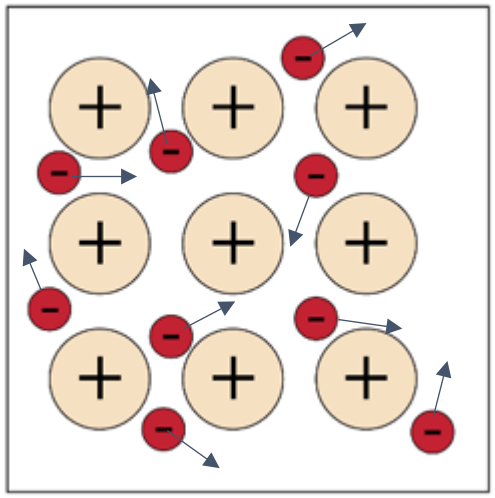
gaseous iron

Answers

7. Iron can conduct electricity because iron atoms can slip over their neighbours and move through the solid.

FALSE

The **iron cations** are normally **fixed** in their lattice positions and cannot move about. It is only the outer shell electrons that are free to move.



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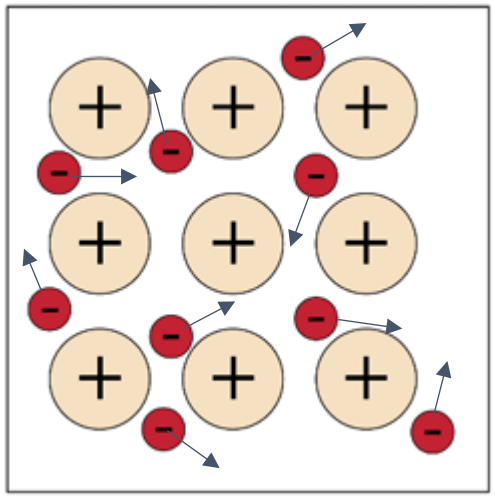
Answers

8. Iron conducts electricity because it contains a ‘sea’ of electrons.

TRUE

The **electrons** from the **outer shells** of atoms can **move about** and will pass through the metal when it is connected to a battery.



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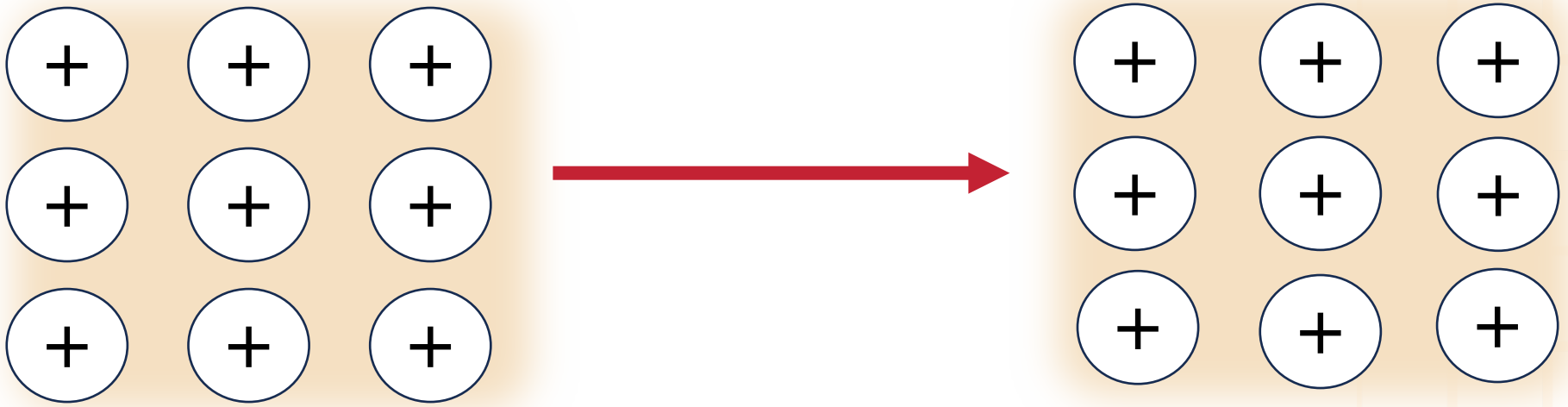
Answers

9. Iron expands when it is heated because iron atoms get bigger.

FALSE

When iron is heated the positive cations **vibrate** and move a little **further apart**.



At lower temperatures, particles vibrate less.

At higher temperatures, particles vibrate more vigorously, and their volume expands.

Answers

10. Iron is a silvery grey metal because iron atoms are silvery grey.

FALSE

The colour of iron is a property of the arrangement of cations and electrons.

A single atom would not have a colour.

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