

Subject: **Chemistry**

Topic: **Properties of Materials**

Application: **Developing medical materials**

**iNVENTiVE**<sup>22</sup>

## Using the worksheet and podcast resources

This worksheet is based on the [Inventive podcast](#).

It supports Gatsby Benchmark 4: Careers in the curriculum by introducing a career and role model. The worksheets are based on topics in the KS3 curriculum.

The short audio clips can be used to provide context to the worksheet and could be played during a lesson.

A QR code on the student sheet links directly to the podcast.

## KS3 National Curriculum statements

### Chemistry

- The properties of metals and non-metals;
- Properties of ceramics, polymers and composites.

The worksheet also links to the following biology topics:

- Biomechanics is the interaction between skeleton and muscles;
- The structure and functions of the human skeleton.

## Audio clips from Inventive podcast.

Available from: [nustem.uk/inventive/#greg](https://nustem.uk/inventive/#greg) (scan QR code)

- **Greg Clip 1:** Trauma plates and other uses of composites; this clip is useful for students to listen to before answering Q6.
- **Greg Clip 2:** Greg talking about apprenticeship route into engineering.

## Other resources

[Greg's career poster](#)

[Greg's employer Invibio](#)

[More information about Greg](#)

## Meet the engineer



**Greg Bowie**

### Manufacturing Engineer

Manufacturing Engineer Greg Bowie uses composite materials to make plastic trauma plates. These plates fix pieces of a broken bone together so the bone can heal. The same composite material is used to cover undersea pipes because it is strong and flexible. At work, Greg experiments with different materials to design a composite with the right physical properties for its job.

## Scan the QR code



to access all the resources and the full podcast from: [nustem.uk/inventive/#greg](https://nustem.uk/inventive/#greg)

## Know

1a. e.g. copper, aluminium, iron, nickel. Alloys like steel, brass are not elements.

1b. e.g. boron, carbon, silicon, sulphur, oxygen. Non-metals like paper, wood, plastic are not elements.

2. a. Copper is used in electric circuits because metals are good electrical conductors and metals are ductile.

b. Copper wires are covered in plastic because non-metals are bad electrical conductors.

c. Aluminium is used for drinks cans because metals are malleable.

d. Saucepans are made from stainless steel because metals conduct heat well.

e. Saucepan handles are made from resin because non-metals do not conduct heat well.

3.

Object	Draw arrows to link words	Property
Biscuit		Flexible
Rubber band		Strong
Phone charger cable		Stiff
Brick		Brittle
Fence post		Elastic

## Apply

4. The composite will have a low density because both plastic and carbon fibres have low density.

The composite is stronger than just plastic because the carbon fibres add strength

The composite is less flexible/stiffer than plastic, and more flexible than carbon fibres

5. Credit anything sensible with a reason e.g.

- The strongest composites are designed so you have to break carbon fibres as well as resin
- Short, narrow fibres - less strong compared to longer fibres because resin can be broken in between fibres.
- Tangled fibres - stronger in all directions than lined-up fibres because you will always need to break some fibres; if they're lined up the composite may have a weaker direction in the same direction
- Wider fibres - probably stronger than the same number of narrow fibres.

## Extend

It would be helpful for students to listen to Clip 6 before answering this question.

6a. Advantages of composites - can be made the correct size/shape; as flexible and strong as bone; more flexible than metal; feels warmer and less heavy than metal; transparent to x-rays so easier to check how the bones are healing; etc;

Disadvantages of composites - more expensive; surgeons have less experience using them; may be hard to obtain.

6b. Includes sensible advantages and disadvantages - composites are more similar to bone than metal is so the patient is less aware of them and there is quicker healing than metal plates. Both the materials are chosen because they won't react inside the body.

## Developing medical materials

### Properties of materials

Metals and non-metals have different physical properties which affect their uses.

- Metallic elements are good thermal and electrical conductors. They are malleable (can be hammered into shape), ductile (can be pulled out into wires) and have a high density. They absorb x-rays.
- Non-metallic elements are usually poor thermal and electrical conductors, brittle (shatter into pieces if bent or hit) and have a low density. X-rays can pass through many non-metals.

Other physical properties of materials include their strength, stiffness and how elastic (stretchy) the material is. Flexible materials are not stiff.

Composite materials are made by combining two or more materials, chosen so the composite has useful physical properties from both materials. Wood is a natural composite. Fibreglass, paper and concrete are manufactured composites.

Alloys are made by combining metals, for example brass (copper and zinc) and steel (iron and carbon).

Polymers are non-metals. Plastics and resins are polymers.

## Meet the engineer



**Greg Bowie**

### Manufacturing Engineer

Greg uses composite materials to make plastic trauma plates. These plates fix pieces of a broken bone together so the bone can heal. The same composite material is used to cover undersea pipes because it is strong and flexible. At work, Greg experiments with different materials to design a composite with the right physical properties for its job.

### Link to Greg's story



## Know

1. Write down 3 metallic elements and 3 non-metallic elements.

2. Complete the following sentences using these phrases:

- metals are good electrical conductors
- non-metals are bad electrical conductors
- metals conduct heat well
- non-metals do not conduct heat well
- metals are malleable
- metals are ductile

a. Copper is used in electric circuits because \_\_\_\_\_ and \_\_\_\_\_.

b. Copper wires are covered in plastic because non-metals are \_\_\_\_\_.

c. Aluminium is used for drinks cans because \_\_\_\_\_.

d. Saucepans are made from stainless steel because \_\_\_\_\_.

e. Saucepan handles are made from resin because \_\_\_\_\_.

3. Match the objects with their physical properties:

Object	Draw arrows to link words	Property
Biscuit		Flexible
Rubber band		Strong
Phone charger cable		Stiff
Brick		Brittle
Fence post		Elastic

## Apply

4. A composite material is used to make plastic trauma plates.

Trauma plates hold broken bones in place inside the body while they heal.

The composite uses these materials:

- Carbon fibres - stiff (don't bend easily), very strong, low density;
- Plastic - flexible (bends easily), low density, strong.

Suggest the properties that this composite will have. Give a reason for each answer.

5. Carbon fibres are added to resin to give strength to a composite. You can change the length and thickness of the fibres to change the properties of the composite for example:

- Long carbon fibres (same direction or tangled, in a matrix);
- Short carbon fibres;
- Narrow or wide carbon fibres.

Suggest how the properties of the composite will change if different shapes and lengths of fibre are used.

## Extend

6. In his job, Greg Bowie uses carbon reinforced plastic composite to make plastic trauma plates. These can be used instead of metal plates.

Metal plates (stainless steel or titanium) are cheaper and have been used for longer than composites.

Metal plates are made by hammering and rolling the metal into the right shape.

Composite plates are made using moulds - plastic is poured in and then carbon fibres are added.

The composite is less stiff, less dense and a worse thermal conductor compared to metal.

It is as flexible and strong as bone. Metal plates block x-rays, but the composite lets x-rays and other scans pass through.

6a. Describe the advantages and disadvantages of using composites for patients with bone fractures.

6b. Write a short paragraph for patients explaining why their surgeon has chosen to use a composite plate.