KS4 Design and Technology theory / revision
Task 1
Plastics can be grouped in three types:

- **Thermoplastics** - these materials can be repeatedly reheated and remoulded.

- **Thermosets** - (thermosetting plastics) - these undergo a chemical change resulting in them becoming permanently rigid, i.e. they cannot be reheated and reshaped.

- **Elastomers** - these are polymers that have good elasticity, i.e. they can be distorted under pressure but will return to their original shape when the pressure is removed.

Properties of plastics

- They are good **electrical** and **thermal insulators**

- They have a **good strength to weight ratio**. This does not mean they are strong materials in the same way that mild steel is strong, but that they have good strength compared to their weight.

- Generally, they have good **atmospheric and chemical corrosion resistance**.
## Common thermoplastics

<table>
<thead>
<tr>
<th>Thermoplastic</th>
<th>Working name</th>
<th>Characteristic</th>
<th>Common</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>Polyethylene Terephthalate</td>
<td>Moderate chemical resistance. Often used for single-use products (but not all the time)</td>
<td>Fibres used to make a wide variety of clothing, bowl-moulded bottles for beers and soft drinks, audio and video tapes, insulation tapes</td>
</tr>
<tr>
<td>HDPE</td>
<td>High Density Polyethylene</td>
<td>High density, good stiffness, good chemical resistance</td>
<td>Crates, bottles, buckets and bowls</td>
</tr>
<tr>
<td>uPVC</td>
<td>Polyvinyl Chloride</td>
<td>Good chemical resistance, good resistance to weathering, rigid, hard, tough, lightweight, can be coloured. Contains dangerous toxins.</td>
<td>Pipes, guttering, bottles and window frames</td>
</tr>
<tr>
<td>LDPE</td>
<td>Low Density Polyethylene</td>
<td>Low density (light weight), low stiffness and rigidity, good chemical resistance</td>
<td>Detergent bottles, toys and carrier bags</td>
</tr>
<tr>
<td>PP</td>
<td>Polypropylene</td>
<td>Lightweight, food-safe, good impact resistance even at low temperatures, good chemical resistance</td>
<td>Kitchen products (food containers), medical equipment, string and rope</td>
</tr>
<tr>
<td>PS</td>
<td>Polystyrene</td>
<td>Lightweight, rigid, colourless, low impact strength</td>
<td>Packaging, disposable cups, / plates and containers.</td>
</tr>
<tr>
<td>Expanded Polystyrene</td>
<td></td>
<td>Floats, good sound and heat insulator, lightweight, low strength</td>
<td>Packaging, disposable cups, sound and heat insulation</td>
</tr>
<tr>
<td>ABS</td>
<td>Acrylonitrile Butadiene Styrene</td>
<td>High impact strength, good toughness with good strength, scratch resistant, light weight and durable</td>
<td>Kitchen products, mobile telephone cases, PC monitor cases, safety helmets, toys, some car parts and domestic telephones</td>
</tr>
<tr>
<td>PMMA</td>
<td>Acrylic</td>
<td>Food-safe, tough, hard, durable, easily machined</td>
<td>Light units, illuminated signs, lenses for car lights</td>
</tr>
<tr>
<td>HIPS</td>
<td>High Impact Polystyrene</td>
<td>Good impact resistance, good strength and stiffness, lightweight</td>
<td>Toys and refrigerator linings</td>
</tr>
</tbody>
</table>
# Thermosets

<table>
<thead>
<tr>
<th>Thermo-plastic</th>
<th>Characteristic</th>
<th>Common</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy resins</td>
<td>High strength when reinforced with fibres (Glass reinforced plastic), good chemical resistance and wear</td>
<td>Surface coating, encapsulation of electronic components, adhesives</td>
</tr>
<tr>
<td>Melamine formaldehyde</td>
<td>Rigid, good strength and hardness, scratch-resistant, can be coloured</td>
<td>Tableware, decorative laminates for work surfaces</td>
</tr>
<tr>
<td>Polyester resins</td>
<td>Rigid, brittle, good heat and chemical resistance</td>
<td>Casting, used in glass reinforced plastic (e.g. boat hulls and car body parts)</td>
</tr>
<tr>
<td>Urea formaldehyde</td>
<td>Rigid, hard, good strength, brittle, heat-resistant, good electrical insulator</td>
<td>Electrical fittings, adhesives</td>
</tr>
</tbody>
</table>

- **Epoxy Resins**
- **Polyester Resin**
- **Melamine formaldehyde**
- **Urea formaldehyde**
Task - Plastics

Watch the following Video Links:
- Printing with ABS: https://www.youtube.com/watch?v=tC_z6jznFPY
- Oreo Vs Epoxy: https://www.youtube.com/watch?v=sNDR14cPif8

1. Explain the three different groups of plastics
2. Plastics have a good strength-to-weight ratio - what does this mean?
3. Why is polypropylene often used for kitchen products?
4. Why is ABS used for phone cases?
5. Why is PMMA often used for light fittings, illuminated signs and lenses for car lights?
6. Why is LDPE used for carrier bags?
7. Urea formaldehyde is often used for plugs, sockets and electrical fittings - why is this?
Task 2
Processing plastics

Polymer processing

Moulding process
- Thermoplastics
  - Injection moulding
  - Blow moulding
  - Extrusion

Forming processes
- Thermoplastics
  - Vacuum forming
  - Thermoforming
  - Line bending

Joining processes
- Thermoplastics
  - Screw fixings
    - Integral snap fixings
    - Captive nuts
    - Adhesives
    - Thermal welding
    - Ultrasonic welding
- Thermosets
  - Screw fixings
  - Adhesives
Moulding thermoplastics: Injection moulding

Step 1
Plastics granules (and any other additives and colours mixed with them) are placed in the hopper. The granule mixture falls through the hopper onto the screw.

Step 2
The screw is rotated via the motor and gearbox. This action forces the polymer forwards towards the heaters, where it becomes softened to the point where it is ready to be injected into the mould.

Step 3
The hydraulic ram forces the softened polymer through the feedhole into the mould. Pressure form the ram ensures the mould cavity has been filled.

Step 4
When sufficient time has passed to allow the polymer to cool and solidify (a matter of seconds), the mould halves are opened. As they open, ejector pins are activated to release the product from the mould.

Step 5
Once emptied, the mould is then closed ready to begin another cycle.

Advantages:
• Very complex shapes can be produced.
• High volumes can be produced with consistent quality.
• Metal inserts can be included in the item being produced.

Disadvantages:
• Initial set up costs are high
• Mould are expensive.

NOTE:
Extrusion is very similar to injection moulding, but can only produce continuous cross-sectional shapes. For example, curtain rails, window frame sections and guttering.

https://www.youtube.com/watch?v=b1U9W4iNDiQ
Moulding thermoplastics - Blow moulding

Step 1
A tube of heated and softened polymer is extruded vertically downwards. This tube is called a Parison.

Step 2
The mould halves close, trapping the upper end of the Parison, effectively sealing it.

Step 3
Hot air is then blow into the Parison forcing it out to follow the shape of the mould.

Step 4
The mould effectively cools the polymer allowing it to be released from the mould.

Step 5
The mould halves are opened and the product is extracted.

Advantages:
• Once set up, blow moulding is a rapid method of producing hollow objects with narrow neck.
• Non-circular shapes can be produced.

Disadvantages:
• Mould can be expensive
• Its difficult to produce re-entrant shapes, i.e. shapes that do not allow easy extraction from the mould (e.g. a dovetail joint).
• Triangular shaped bottles are difficult to produce.

https://www.youtube.com/watch?v=AD_Y4yZc54U
Vacuum Forming is a method of forming plastic that is common in schools used to produce trays, cartons, lids etc. This is used in batch or mass production to make food packaging within the packaging industry. It is done by heating a clamped sheet of thermoplastic until soft, it is then extracted so that the plastic is sucked down forming a mould. The mould must be shaped so that it easily comes off it is then tapered so that it has a smooth finish and smoothed edges.

**Step 1**
Mould is placed inside a machine where the plastic sheet is clamped to the top of the box using a toggle clamp. The heater is moved into position to heat the plastic until it softens.

**Step 2**
The heater is pushed back and the mould is then lifted into the hot plastic before the vacuum pump is turned on.

**Step 3**
The air between the mould and the softened thermoplastic is sucked out by the pump. The plastic will be forced down over the mould, creating a sharp definition.

**Step 4**
The sheet is unclamped from the frame and the mould is removed. Excess material around the moulding is trimmed off.

**NOTE:**
Thermoforming is very similar to vacuum forming. Instead of using a vacuum to ‘pull’ the softened polymer around a mould, thermoforming uses an outer mould to help in the process. This allows a greater level of detail, such as lettering, symbols and sharp edges to be achieved.

https://www.youtube.com/watch?v=hukafUxglmE
https://www.youtube.com/watch?v=KGAuunWs8io
Forming thermoplastics - Line bending

Line bending is the simplest method of forming thermoplastics. A strip heater that has a narrow opening allows heat to escape in a restricted area. This then heats and softens the plastic in a concentrated line. Acrylic is popular within schools it can be line bent easily and safely.

By using formers or jigs you can increase the accuracy of bending certain angles, they also help to hold work still as it cools.

https://www.youtube.com/watch?v=yT9EXnmRpHs
Knowledge recall Questions

1. Read the notes and watch the videos of each plastic process
2. Make an overview of / categorise different plastic processes for both thermoplastics and thermosetting plastics.
3. State two advantages of injection moulding
4. How is the polymer moved along in the injection moulding process?
5. What is extrusion?
6. What products does the blow moulding process produce?

Deeper thinking tasks:

1. Using notes, sketches / diagrams, fully explain the following processes with reference to advantages, disadvantages and examples of use:
   1. Injection moulding
   2. Blow moulding
   3. Vacuum forming
   4. Line bending
Task 3
Composite Materials

Fibre-reinforced composites
- Natural woods
- Polymers mixed with fibres
  - GRP
  - Plastic laminates
  - Carbon fibre
- Elastomers mixed with fibres
- Concretes mixed with fibres

Sheet-based composites
- Man-made boards
  - Plywood
  - Blockboards
  - MDF
  - Hardboard
  - Chipboard
  - Sterling board
  - Hexaboard
  - Maplex
- Man-made boards
  - Metal / polymer sheet

Particle-based composites
- Cements
  - Tungsten carbide
  - Titanium carbide
- Filament-reinforced ceramics
  - Tungsten mesh and ceramics
  - Zirconia reinforced with titanium
- Concretes
- Tarmac
Composite Materials

- Composite materials are produced by mixing two or more materials together. The main advantage of this is that the properties from each of the materials can be enhanced and utilised.

- Plastics have useful strength and rigidity with lightweight with good electrical insulation properties.

- These properties can be enhanced by adding other materials to produce fibre-reinforced polymers (FRP)

- There are three main groups of composite materials (see diagram):
  - Fibre-reinforced composites
  - Particle-based composites
  - Sheet-based composites

- The most important of these are the fibre-reinforced composites, since these are more commonly used in the manufacture of products.

- By adding strands (fibres) of glass to polyester resin, a very tough, rigid lightweight material can be produced i.e. glass reinforced plastics (GRP)

- ‘Man-made’ materials refers to those sheet or moulded materials where wood or wood fibre are bonded together to form an new material

- Man made boards have increased stability against warping and have equal strength in all directions- unlike natural timbers
Composite Materials

The general properties of common fibre-reinforced composites are:

- They have a good strength to weight ratio (i.e. lightweight with low density and strong compared to their weight).
- They are resistant to corrosion.
- They have good fatigue resistance.
- They possess a low thermal expansion.

Carbon fibre-reinforced polymer

- Carbon fibre composite products are manufactured in a similar way to GRP.
- The carbon fibres are mixed with resin, then heated in a mould to produce a composite that is much stronger than GRP.
- Its strength makes it suitable for producing protective components for a modern Formula One racing car, or high performance sports or aerospace products.

Glass fibre-reinforced polymer

- This is a type of a fibre-reinforced polymer. Glass is spun to produce a fibre that is then coated to aid bonding to the resin.
- Fibres of glass are available in a variety of gauges (thicknesses) from coarse (30µm) to very fine (5µm). Note: 1µm=0.001mm.

Carbon fibre wing mirror  Carbon fibre Helmet

Fibre glass canoe  Fibre glass slide
Task - Composites

1. What is the advantage of composite materials and how are they produced?
2. What are the three main groups of composite materials?
3. How are fibre-reinforced polymers made? Include images where possible
4. State the general properties of common fibre-reinforced composites.
5. Produce a ‘case study’ for both:
   1. Carbon fibre-reinforced polymer
      ▶ Examples
      ▶ Production processes
      ▶ Properties
      ▶ Advantages
      ▶ Disadvantages
   2. Glass fibre-reinforced polymer
      ▶ Examples
      ▶ Production processes
      ▶ Properties
      ▶ Advantages
      ▶ Disadvantages
Task 4
A Smart material can be defined as a material whose physical properties change in response to an input. Designers and manufacturers are utilising smart materials in the creation of new consumer products, often making them simpler and easier to use.

Smart materials respond to different factors:

- Changes in temperature
- Changes in light levels
- Changes in pressure (force)

You need to know about 3 smart materials:

- Shape memory Alloys (SMA) e.g. Nitinol
- Thermochromic pigments
- Photochromic pigments
Shape memory alloys are metals that have been designed to work in a particular way in response to the stresses and strains placed on them.

The most common is called ‘nitinol’ - an alloy of nickel and titanium. Other SMA can contain a range of other materials such as iron, nickel, cobalt and titanium alloys in varying percentages.

Heat treatment gives the material a memory. For example, a nitinol wire heated by passing an electrical current through it will reduce in length by about 5%. On releasing the current, the wire can be stretched back to its original length.

This material has application in bio-engineering. E.g. a stent tube (nitinol tube in the form of mesh) can be collapsed when chilled. When inserted into a blocked or collapsed artery it will resume its original shape it reaches body temperatures, thereby allowing blood to flow through the vein once again.

Another example includes the plating of broken bones. As the plates reach body temperature, they remember to contract, pulling the fracture together and applying pressure to help bones heal quicker. Normal stainless steel plates tend to slacken causing the bones to move apart again which would delay healing.

‘Memoflex’ glasses are a further example of the use of SMA. These are also nickel / titanium alloys that have the ability to return to their original shape at room temperature after being deformed.

Video clip: https://youtu.be/-K57cbOhA5g
Thermochromatic pigments

- These are colour pigments that can change colour in response to heat. The pigments are usually combined with polymers as plastics products are moulded.

- The Russell Hobbs 2001 ‘Thermocolour’ kettle, often referred to as the ‘pink kettle’, changes from a cool blue colour when cold to a vibrant pink as it boils. The colour change is also a good safety feature i.e. red associated with danger.

- Baby feeding products, such as bowls, spoons and cups made from Tommy Tippee, use thermochromic pigments in their manufacture - again, useful safety function.

Thermocolour film

- These pigments are a special type of liquid crystal which when heated will change colour. This has led to the development of temperature testing strips for medical and other applications.

Thermometers

- Traditional mercury thermometers can be difficult to read and are extremely dangerous to use with young children. Thermochromic pigments can be engineered to change colour across a range of temperatures. This allows for simple measuring scales.

Batteries

- Battery test strips incorporate thermochromatic ink onto a material that heats up as a current passes through. If the battery has sufficient energy to heat up the strip, then it will change colour indicating that the battery is in good condition.
Photochromic pigments react to changes in light levels. Photochromic ink darkens as the light level increases. Some photochromic inks change colour.

The UV light causes the darkening of the ink, which means the ink works best in natural light. This special ink has two main applications; sunglasses and spectacles. However, it is also used in novelty items such as embroidery thread and toys, where colour change takes place according to light level. Nail lacquer/varnish is also available with photochromic technology.

Modern photochromic lenses are manufactured from plastic. The ‘blank’ lenses are carefully heated in a special oven, so that photochromic ink is absorbed by the surface layer. It is the ink molecules in the surface layer of the lens that change shape, due to a chemical reaction caused by UV light. The brighter the natural light (sunlight), the darker the lenses appear.

The tint of a photochromic lens changes according to the intensity of natural light (UV light). Inside a building, the lenses remain clear but they darken when outside in sunlight. Spectacles with this type of lens are comfortable to wear, in all conditions. However, they are more expensive than spectacles with normal, clear lenses.

It is possible to buy nail varnish that changes colour according to the intensity of natural sunlight. The nail varnish/lacquer takes advantage of photochromic technology.

Video clip: https://youtu.be/pnsVks0SshA
Task - Smart Materials

1. Define ‘smart materials’ and explain what factors they respond to

2. Investigate the different types and application of smart materials:
   1. Shape memory alloy
   2. Thermochromatic pigment
   3. Photochromic pigment
Task 5
Modern Materials

- Modern materials are considered to be those that have only been available in their present form since the 1960s/70s onwards - some being experimental materials for many years before this.

- These materials cannot be considered smart since they do not react in anyway to the environment in which they are used.

- You need to know about 4 modern materials:
  - Kevlar
  - Precious metal clay
  - high density modelling foam
  - Polymorph

Kevlar

- Kevlar has five times the strength to weight ratio of steel. The fibres cannot be twisted so they are woven flat and it is this that make it such as useful material for protection as a bullet- and knife-proof vests.

- Protection is achieved by applying a number of layers to the garment. Although very structured it remains flexible.

- Kevlar is also used in the aerospace industry as linings for jet-engine casings.

- When mixed with a polymer, it can be formed to produce armour plating in helicopters, vehicles and helmets.
Precious metal clay

- Mainly used by jewellery makers. This material enables shapes to be formed in much the same way as when using ‘ordinary’ pottery clay.

- Made up of 99.9% silver (or gold) with a clay binder and water and feels like, and works the same way, as clay. Because of this, simple modelling tools can be used to create the desired shape.

- This is often much quicker than preparing patterns and moulds for casting. PMC commonly used to make bespoke jewellery.

- Work is air dried and then fired (heated) to near melting point so that the precious metal particles fuse together to make a solid metallic object.

- After firing, the object can be soldered, enamelled and polished as necessary.

High density modelling foam

- Commonly known and styrofoam

- Available in large flat sheets of different thicknesses ranging from 15mm to 100.

- It can be shaped using hand and machine tools and takes fine detail well- intricate / complex shapes can be formed. It is often used on computer numerically controlled milling machines.

- Allows 3D shapes / models to be produced quickly- very useful in the development stages of a product- to realise the size and shape of a design idea.

- It can be easily cut using a range of hand tools such as a coping saw and finished with files and abrasive paper.
Polymorph

- Polymorph is a low melting point polymer that find useful applications in prototyping. It softens at 60°C making it possible to fuse the grains of material together followed by manipulation of the material to create the desired shape.
- Reheating in hot water will allow for further work to be carried out.
- Students often use polymorph to make prototype handle grips or even to simulate an injection moulded plastic product.

Task - Modern Materials

1. Define ‘modern materials’
2. Investigate (explain material and justify applications for):
   1. Kevlar
   2. High density modelling foam
   3. Polymorph
   4. Precious metal clays

Extending your learning

There are a lot of modern materials used in many aspects of life. Conduct independent research into:

1. Fibre optics
2. Liquid crystal displays
3. Engineered timbers
4. Metal foams
Task 6
Materials - Metals

**Common Metals**

- **Ferrous metals**
  - Cast irons
  - **Steels**
    - Mild steel
    - Medium carbon steel
    - High carbon steel
  - **Non-ferrous metals**
    - Aluminium
    - Copper
    - Lead
    - Tin
    - Zinc
  - **Ferrous alloys**
    - Stainless steel
    - High speed steel
    - Die (tool) steel
  - **Alloys**
    - Non-ferrous alloys
      - Brass
      - Bronze
      - Duralumin(s)

**Ferrous metals:** metals that contain iron (ferrite) and carbon

**Non-ferrous metals:** metals that do not contain iron (ferrite) and carbon

**Ferrous alloys:** at least one contains iron

**Non-ferrous alloys:** at least one contains iron
Ferrous metals: iron and steel

- Iron is produced directly from its ore through the use of a blast furnace.
- The material that is produced is called ‘pig iron’ - this is a low quality material and cannot be used commercially.
- Pig Iron is ‘converted’ into steel by the introduction of carbon into its structure.
- Iron is generally soft and ductile which does not make it a very commercially useful material.
- When carbon is mixed with iron, it greatly improves its properties:
  - Becomes harder
  - Toughness reduces
  - Can be heat treated to make them even stronger and harder.

<table>
<thead>
<tr>
<th>Base material</th>
<th>Additional element (carbon)</th>
<th>Type of steel</th>
<th>Ductility</th>
<th>Hardness</th>
<th>Toughness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>&lt;0.3%</td>
<td>Low carbon steel (mild steel)</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td></td>
<td>0.3-0.6%</td>
<td>Medium carbon steel</td>
<td>↑</td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.6-1.7%</td>
<td>High carbon steel</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td></td>
<td>3.5%</td>
<td>Cast iron</td>
<td>↓</td>
<td>↑</td>
<td>Brittle</td>
</tr>
</tbody>
</table>
Non-Ferrous metals

- Do not contain iron.
- Include aluminium, copper, lead, zinc, and tin. Also includes precious metals such as silver gold and platinum.
- Aluminium is the most abundant ore (Bauxite) in the earth’s crust but it is not the most process metal—mild steel is.
- This is because aluminium is more difficult to process—large amount of energy is needed.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Melting temperature</th>
<th>Common uses and properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>660°C</td>
<td>Kitchenware, such as saucepans, overhead power cables, it is an excellent conductor of electricity when drawn into wire.</td>
</tr>
<tr>
<td>Copper</td>
<td>1083°C</td>
<td>Electrical contacts, domestic pipe work for central heating and water, jewellery and electrical cables (in wire form).</td>
</tr>
<tr>
<td>Gold</td>
<td>1063°C for fine gold</td>
<td>Electrical contacts for switches and credit / telephone SIM cards, jewellery.</td>
</tr>
<tr>
<td>Lead</td>
<td>330°C</td>
<td>Very soft but heavy metal used for flashing between roofs and adjoining brickwork; very durable.</td>
</tr>
<tr>
<td>Platinum</td>
<td>1755°C</td>
<td>Used as a precious metal in jewellery.</td>
</tr>
<tr>
<td>Silver</td>
<td>960°C for fine silver</td>
<td>Expensive cutlery and various decorative items, also used in process of photographic film.</td>
</tr>
<tr>
<td>Tin</td>
<td>232°C</td>
<td>Rarely used in pure state. Applications include food wrapping (foil) and coating for steel plate in the manufacture of food cans.</td>
</tr>
<tr>
<td>Titanium</td>
<td>1675°C</td>
<td>Good strength / weight ratio and is a very clean material—suitable for surgical applications such as hip replacements. Also used for glasses frames.</td>
</tr>
<tr>
<td>Zinc</td>
<td>419°C</td>
<td>Used as coating for steel. i.e. galvanised steel; used for the manufacture of buckets, and casings for electrical units; can be die cast to produce high detail products, such as lock mechanisms and small gear.</td>
</tr>
</tbody>
</table>
Alloys and alloying

- The alloying of metals (mixing two or more metals together) can produce a material with enhanced properties.
- Individual metals have a limited range of properties that can only be enhanced by heat-treating them in some way. So by combining metals, we have improved the properties.
- For example, adding zinc to copper produces a much harder and stronger material than pure copper.
- Alloying changes other characteristics of the material. i.e. Mixing copper with zinc to make brass changes the colour of the metal to a yellow / gold making the material attractive to purchases.

### Benefits of alloying
- Changes the melting point
- Changes the colour
- Increases strength, hardness and ductility
- Enhances resistance to corrosion and oxidation
- Changes electrical/thermal properties
- Improves flow properties, producing better castings.

### Name | Base metal | Composition | Common use
--- | --- | --- | ---
Duralumin | Aluminium | 4% copper 1% manganese 0.1% magnesium | Structural components for aircraft
Brass | Copper | 35% zinc | Cast valves and taps, boat fittings and ornaments
Bronze | Copper | 10% tin | Statues, coins, bearings
Nitinol | Nickel | Nickel, titanium | Smart metal alloys for making springs and muscle wires.
Alloying steels

- Alloying steels with elements such as chromium and nickel will produce a stainless steel - a well known group of metals with good corrosion resistance, hardness, strength and toughness.
- Most metals, steel included, will become less hard and more ductile when heated.
- By alloying with tungsten, chromium and cobalt, a range of ‘high speed steels’ can be produced, which do not lose their cutting edges when working at high temperatures.

<table>
<thead>
<tr>
<th>Alloy steel</th>
<th>Alloyed with</th>
<th>Characteristics</th>
<th>Common use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td>Chromium, nickel</td>
<td>Tough and wear-resistant;</td>
<td>Sinks, cutlery, sanitary-ware</td>
</tr>
<tr>
<td></td>
<td>magnesium</td>
<td>corrosion resistant</td>
<td></td>
</tr>
<tr>
<td>High speed steel (HSS)</td>
<td>Tungsten, chromium, vanadium</td>
<td>Very hard, will cut while at red heat</td>
<td>Cutting tools, such as drills</td>
</tr>
<tr>
<td>Tool and die-steels</td>
<td>Chromium, manganese</td>
<td>Very hard and tough, with excellent wear-resistance</td>
<td>Fine press tools, extruder dies,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>blanking punches and dies, some hand tools</td>
</tr>
<tr>
<td>High tensile steels</td>
<td>nickel</td>
<td>Good tensile strength and</td>
<td>Car engine components</td>
</tr>
<tr>
<td></td>
<td></td>
<td>toughness, generally corrosion-resistant</td>
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Task - Metals

1. Make a copy of metal overview showing the variety and classification of metals

2. Investigate the following types of metal:
   - Ferrous metal
   - Non Ferrous metals
   - Alloys
   - Alloying steel

For each section, include general information of the category, all specific metals listed with an explanation of uses.

Present the information however you want, but remember these will form part of your revision notes.