Energy transfer and efficiency

Different types of energy can be transferred from one form to another. For example, chemical energy is transferred into kinetic energy in a car engine. The process of transferring energy is shown using an energy transfer diagram. A very efficient device can transfer a greater proportion of useful energy.

Heat can be transferred by conduction, convection and radiation. Dark matt surfaces are better at absorbing heat energy than light shiny surfaces. Heat energy can be lost from homes in many different ways. There are different ways to reduce these heat losses.

1. Forms of energy
2. Energy transfer
3. Efficiency
4. Heat transfer
5. Heat transfer (Higher Tier)
6. Reducing heat loss

Forms of energy

You should be able to recognise the main types of energy. One way to remember the different types of energy is to learn this sentence:

Most Kids Hate Learning GCSE Energy Names

Each capital letter is the first letter in the name of a type of energy.

<table>
<thead>
<tr>
<th>Type of energy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic</td>
<td>Energy in magnets and electromagnets</td>
</tr>
<tr>
<td><strong>Kinetic</strong></td>
<td>The energy in moving objects. Also called movement energy.</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Heat</strong></td>
<td>Also called thermal energy.</td>
</tr>
<tr>
<td><strong>Light</strong></td>
<td>Also called radiant energy.</td>
</tr>
<tr>
<td><strong>Gravitational potential</strong></td>
<td>Stored energy in raised objects.</td>
</tr>
<tr>
<td><strong>Chemical</strong></td>
<td>Stored energy in fuel, foods and batteries.</td>
</tr>
<tr>
<td><strong>Sound</strong></td>
<td>Energy released by vibrating objects.</td>
</tr>
<tr>
<td><strong>Electrical</strong></td>
<td>Energy in moving or static electric charges.</td>
</tr>
<tr>
<td><strong>Elastic potential</strong></td>
<td>Stored energy in stretched or squashed objects.</td>
</tr>
<tr>
<td><strong>Nuclear</strong></td>
<td>Stored in the nuclei of atoms.</td>
</tr>
</tbody>
</table>
Energy transfer

You should recall from your Key Stage 3 studies how to draw and interpret an energy transfer diagram.

Different types of energy can be transferred from one type to another. Energy transfer diagrams show each type of energy, whether it is stored or not, and the processes taking place. Sankey diagrams also show the relative amounts of each type of energy.

Energy transfer diagrams
The energy transfer diagram (below) shows the useful energy transfer in a car engine. You can see that a car engine transfers chemical energy, which is stored in the fuel, into kinetic energy in the engine and wheels.

This diagram shows the energy transfer diagram for the useful energy transfer in an electric lamp. You can see that the electric lamp transfers or converts electrical energy into light energy.

Notice that these energy transfer diagrams only show the useful energy transfers. However, car engines are also noisy and hot, and electric lamps also give out heat energy.
Sankey diagrams
Sankey diagrams summarise all the energy transfers taking place in a process. The thicker the line or arrow, the greater the amount of energy involved. The Sankey diagram for an electric lamp (below) shows that most of the electrical energy is transferred as heat rather than light.

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<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical</td>
<td>100 J</td>
</tr>
<tr>
<td>Light</td>
<td>10 J</td>
</tr>
<tr>
<td>Heat</td>
<td>90 J</td>
</tr>
</tbody>
</table>
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Efficiency
You should know that energy can be 'wasted' during energy transfers, and you should be able to calculate the efficiency of a device.

'Wasted' energy
Energy cannot be created or destroyed. It can only be transferred from one form to another or moved. Energy that is 'wasted', like the heat energy from an electric lamp, does not disappear. Instead, it is transferred into the surroundings and spreads out so much that it becomes very difficult to do anything useful with it.

Electric lamps
Ordinary electric lamps contain a thin metal filament that glows when electricity passes through it. However, most of the electrical energy is transferred as heat energy instead of light energy. This is the Sankey diagram for a typical filament lamp.
Modern energy-saving lamps work in a different way. They transfer a greater proportion of electrical energy as light energy. This is the Sankey diagram for a typical energy-saving lamp.

From the diagram, you can see that much less electrical energy is transferred, or "wasted", as heat energy.

Calculating efficiency
The efficiency of a device such as a lamp can be calculated using this equation:

\[
\text{efficiency} = \frac{\text{useful energy transferred}}{\text{energy supplied}} \times 100
\]

The efficiency of the filament lamp is \(10 \div 100 \times 100 = 10\%\). This means that 10\% of the electrical energy supplied is transferred as light energy (90\% is transferred as heat energy).

The efficiency of the energy-saving lamp is \(75 \div 100 \times 100 = 75\%\). This means that 75\% of the electrical energy supplied is transferred as light energy (25\% is transferred as heat energy). Note that the efficiency of a device will always be less than 100\%. 
Heat transfer

You should know that heat energy can be transferred from one place to another by conduction, convection and radiation.

**Conduction**
Heat energy can move through a substance by conduction. Metals are good conductors of heat, but non-metals and gases are usually poor conductors of heat. Poor conductors of heat are called insulators. Heat energy is conducted from the hot end of an object to the cold end.

**Convection**
Liquids and gases are fluids. The particles in these fluids can move from place to place. Convection occurs when particles with a lot of heat energy in a liquid or gas move and take the place of particles with less heat energy. Heat energy is transferred from hot places to cooler places by convection.

**Radiation**
Objects release heat energy as infrared radiation. The hotter an object is, the more infrared radiation it emits or radiates. No particles are involved in radiation, unlike conduction and convection, so radiation can even work through the vacuum of space. This is why we can still feel the heat of the sun although it is 150 million km away from the Earth.

Some surfaces are better than others at reflecting and absorbing infrared radiation. The table below summarises this.

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<tr>
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<th>Ability as an absorber</th>
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</thead>
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<td>dark</td>
<td>dull or matt</td>
<td>poor</td>
<td>good</td>
</tr>
<tr>
<td>light</td>
<td>shiny</td>
<td>good</td>
<td>poor</td>
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</table>

Many domestic radiators are painted with white gloss paint. They would be better at radiating heat if they were painted with black matt paint. Radiators transfer most of their heat to a room by convection.
Heat transfer (Higher Tier)

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**Convection**
Liquids and gases expand when they are heated. This is because the particles in liquids and gases move faster when they are heated than they do when they are cold. As a result, the particles take up more volume. This is because the gap between particles widens, while the particles themselves stay the same size.

The liquid or gas in hot areas is less dense than the liquid or gas in cold areas, so it rises into the cold areas. The denser cold liquid or gas falls into the warm areas. In this way, convection currents are set up that transfer heat from place to place.

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**Radiation**
Radiation involves the transfer of heat by infrared radiation. This is a type of electromagnetic radiation and involves waves.
Reducing heat loss

You should be able to describe how heat energy is lost from buildings and to explain how these losses can be reduced.

Heat escape routes
The diagram shows some of the sources of heat loss from a house and how to reduce them.

Heat energy is transferred from homes by conduction through the walls, floor, roof and windows. It is also transferred from homes by convection. For example, cold air can enter the house through gaps in doors and windows, and convection currents can transfer heat energy in the loft to the roof tiles. Heat energy also leaves the house by radiation through the walls, roof and windows.

Ways to reduce heat loss
There are some simple ways to reduce heat loss, including fitting carpets, curtains and draught excluders. Heat loss through windows can be reduced using double glazing. There may be air or a vacuum between the two panes of glass. Air is a poor conductor of heat, while a vacuum can only transfer heat energy by radiation. Heat loss through walls can be reduced using cavity wall insulation. This involves blowing insulating material into the gap between the brick and the inside wall, which reduces the heat loss by conduction. The material also prevents air circulating inside the cavity, therefore reducing heat loss by convection. Heat loss through the roof can be reduced by laying loft insulation. This works in a similar way to cavity wall insulation.
Test Questions

1. What is the useful energy transfer in a radio?

a) Electrical to sound
b) Electrical to light
c) Electrical to heat

2. What form of energy is stored in a battery?

a) Electrical
b) Chemical
c) Light

3. The efficiency of an electric lamp is 25%. If it receives 100J per second of electrical energy, how much of this is transferred as light energy?

a) 25J/s
b) 75J/s
c) 75W

4. What substances can convection happen in?

a) Solids and gases
b) Solids and liquids
c) Liquids and gases

5. What type of radiation do hot objects emit?

a) Infrared radiation
b) Microwave radiation
c) Gamma radiation
6. The best absorbers of heat are:

a) Light, dull surfaces  
b) Black, shiny surfaces  
c) Black, dull surfaces

7. The worst reflectors of heat are:

a) Light, shiny surfaces  
b) Light, dull surfaces  
c) Black, dull surfaces

8. Heat passes through a single pane of window glass by:

a) Conduction  
b) Convection  
c) Radiation
1. Answer a
   In a radio the electrical energy is converted into sound energy

2. Answer b
   A battery has energy stored in the form of chemical energy

3. Answer a
   Though the light bulb is getting 100 J of energy, it's efficiency is only 25% so the only 25% of total amount of energy will be used i.e. 25 J.

4. Answer c
   Convection is only possible in liquids and gases, the same procedure in solids is referred to as conduction

5. Answer a
   Hot objects emit infra red transmission

6. Answer c
   Black colour is a good absorbent and thus black and dull surfaces are good absorbers of heat

7. Answer c
   The black dull surfaces are also worst reflectors of heat since they are good absorbers.

8. Answer a
   Heat can pass through a window pane through the process of conduction