Physics Revision

# Physics 1

## Energy Transfer

### Infrared Radiation

**Thermal radiation is the transfer of thermal energy by electromagnetic waves; no particles of matter are involved.**

All objects emit and absorb thermal radiation, depending on surface, shape, and dimensions. The hotter the object the more energy it radiates.

If there is a big difference in temperature between and object and its surroundings then it will emit or absorb energy faster – therefore the rate of thermal radiation can be slowed by using insulation, which provides a barrier.

Different materials transfer heat at different rates.

1. Dark matt surfaces emit more radiation than light shiny surfaces
2. Dark matt surfaces absorb more radiation than shiny surfaces – as shiny surfaces are better reflectors of infrared.

### Kinetic Theory

The amount of energy held by particles is different in solids, liquids, and gases.

1. In solids the particles have the least, they are not able to move but do vibrate around a fixed point
2. In liquids the particles have a bit more energy – enough to move around though not far apart
3. In gases the particles have more energy this means they can move quickly

### Conduction

**Conduction is the transfer of heat energy without the substance itself moving.**

The structure of metals makes them good conductors of heat.

As a metal becomes hotter, its tightly packed particles gain more kinetic energy and vibrate. This energy is transferred to cooler parts of the metal by delocalised electrons, which move freely through the metal, colliding with particles and other electrons.

Conduction also occurs in non-metal solids because the particles can pass energy from one to the next by vibration.

However the lack of free electrons makes most non-metals bad conductors. Gases are bad at conducting as the particles are so far apart.

### Convection

**Convection is the transfer of heat energy through movement. This occurs in liquids and gases and creates convection currents.**

In liquids and gases the particles closest to the heat source move fastest and so become further apart. This causes the substance to expand and it becomes less dense.

The warm part rises up and becomes colder, denser liquid or gas moves into the space created and the cycle continues.

### Condensation

**Condensation occurs when a warm gas comes in contact with a cold surface.**

The particles in a gas have more energy than those in a liquid. When a gas condenses this energy is released leading to a temperature increase.

The surface needs to be cold enough to cool the particles so that they no longer have enough energy to move around as quickly as a gas. The colder the surface the greater the rate of condensation.

### Evaporation

**A liquid evaporates when its particles have gained enough energy to escape the surface of the liquid and become a gas.**

When you get out of the pool the water evaporates taking the heat away with it making you feel cold.

### Applications of Energy Transfer

#### The Rate of Heat Transfer

The rate of heat transfer is effected by:

1. A large surface area compared to volume will gain and lose heat quicker – desert foxes have large ears to lose heat quickly, arctic foxes have smaller ears to minimise heat loss
2. Different materials transfer heat at different rates – fur, feathers and human clothing are more conductors so reduce heat loss
3. Humans sweat and dogs pant – as the moisture on our skin evaporates taking heat with it.
4. The surface the object is in contact with – when you stand bare footed on tiles they feel colder than carpet as they are a good conductor whilst carpet is an insulator.
5. The bigger the temperature difference between an object and its surroundings the faster it transfers heat – in a cold winter the house costs more to heat than in a mild winter , as the house loses heat quicker.

##### http://apphysicsc.com/wp-content/uploads/2012/10/vacuum-flask.gifVacuum Flask Example

A flask greatly reduces heat flow from the inside to the outside and vice versa. This means that it will keep hot drinks hot and cold drinks cold.

A flask is made of plastic, which is a poor conductor.

The shiny silvered sides reflect infrared radiation and stop heat transfer.

The vacuum contains no particles so conduction and convection can’t take place.

The stopper prevents evaporation from the surface and convection currents at the top.

### Heating and insulating buildings

#### U-Values

**The U-Value of a material shows how effective an insulator it is. The lower the u-value the better the insulator (it means heat flows slowly threw it)**.

#### Efficiency and Payback time

It is important to consider u-values when building a house, and to compare the insulating benefits against the cost.

The payback time of an improvement tells us how long it takes, in efficiency savings, to recoup the cost. Payback time can be used to work out the cost effectiveness of different types of insulation/improvements also.

*Payback Time = Total Cost of Improvement / Savings per Year*

*[years] = [£] [£]*

### Specific Heat Capacity

**The specific heat capacity of a substance is the amount of energy needed to change the temperature of 1kg of it by one degree Celsius.**

*Energy Transferred = Mass \* Specific Heat Capacity \* Temperature Change*

*[J] = [kg] [J/kg] []*

This information is useful when deciding materials for projects – e.g. water has a high specific heat capacity which means it can store a lot of heat energy without getting too warm making it a useful coolant.

Water is used in solar panels on a roof to absorb energy from the sun, the water in the panel store a lot of heat energy is used to heat buildings and provide hot water.

Solar Panels are often black with a large surface area to absorb as much infrared as possible.

### Ways energy is transferred in realtion to objects

#### homes

Heat energy is transferred from homes into the environment by:

**Conduction** – through walls, floor, roof, and windows.

**Convection** – convection currents along with cold draughts (from gaps) cause heat energy carried by warm air to rise up to the roof where it is easily lost.

**Radiation** – from the surfaces of the walls, roof, and through windows.

|  |  |  |  |
| --- | --- | --- | --- |
| Where Heat is lost | Preventative Methods | Benefits | Problems |
| Roof | -roof Insulation – traps a layer of air between fibres or insulating material | -Can reduce heat loss by 20-25%  -Many different methods to suit all homes  -Short payback time | -Requires suitable safety precautions to be taken |
| Under doors and windows | -draught excluders | -Can reduce heat loss by 15%  -Cheap an easy to install  -Short payback time | -Must make sure that air vents aren’t blocked –to prevent dry rot |
| Walls | -cavity wall insulation and internal thermal boards | -Can reduce heat loss by 35% | -Expensive  -Long payback time |
| Windows | -double glazing – traps air between two sheets  -curtains – stop heat loss from convection | -Double glazing can reduce heat loss by up to 10%  -Curtains are cheap and easy | -Double glazing is expensive and has a long payback time |
| Floor | -carpets, rugs, and under floor insulation can help stop heat loss | -Carpets are easy to install | -Under floor insulation costs a lot and it has a large payback time |

## Energy and Efficiency

### Transferring energy

When energy is transferred only part of the energy is transferred to what we wanted. The rest is 'wasted'.

Wasted energy is eventually transferred to the surroundings, which become warmer. As energy is dissipated to the surroundings it becomes more spread out and so less useful.

Replacing old technology with new technology (efficient) means that less energy is wasted. When deciding we need to look at the cost effectiveness of replacement, we use payback time also.

### Efficiency

**The greater the proportion of energy that is usefully transferred, the more efficient we say the device is.**

Efficiency can be calculated using power or energy, and can be a decimal or percentage.

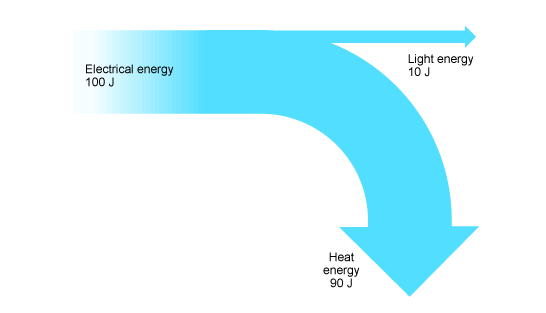
*Efficiency = Useful Energy out / Total Energy supplied*

*Efficiency = Useful Power out / Total Power supplied*

*E.g. 5 / 100 = 0.05 or \*100 for a percentage = 5% efficient*

### Sankey Diagram

**Sankey diagrams show energy transfers.**

They provide a visual representation of how much energy there is of each type - the widths of the arrows are proportional to the amount of energy they represent.

The Sankey diagram shows a standard electrical bulb. It shows most of the energy is wasted as heat energy. The useful energy is shown straight.

**Energy cannot be destroyed**. When drawing a Sankey diagram the total out must equal the total in.

**May use squares also.**