Chapter 11. Thermal Energy Transfer

Contents:

New word list:

2.3 Transfer of thermal energy

2.3.1 Conduction

Core

1 Describe experiments to demonstrate the properties of good thermal conductors and bad thermal conductors (thermal insulators)

Supplement

2 Describe thermal conduction in all solids in terms of atomic or molecular lattice vibrations and also in terms of the movement of free (delocalised) electrons in metallic conductors

3 Describe, in terms of particles, why thermal conduction is bad in gases and most liquids

4 Know that there are many solids that conduct thermal energy better than thermal insulators but do so less well than good thermal conductors

2.3.2 Convection

Core

1 Know that convection is an important method of thermal energy transfer in liquids and gases

2 Explain convection in liquids and gases in terms of density changes and describe experiments to illustrate convection

Supplement

2.3.3 Radiation

Core

1 Know that thermal radiation is infrared radiation and that all objects emit this radiation

2 Know that thermal energy transfer by thermal radiation does not require a medium

3 Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of infrared radiation

Supplement

4 Know that for an object to be at a constant temperature it needs to transfer energy away from the object at the same rate that it receives energy

5 Know what happens to an object if the rate at which it receives energy is less or more than the rate at which it transfers energy away from the object

6 Know how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted from the Earth's surface

continued

2.3 Transfer of thermal energy continued

2.3.3 Radiation continued

Core

Supplement

7 Describe experiments to distinguish between good and bad emitters of infrared radiation

8 Describe experiments to distinguish between good and bad absorbers of infrared radiation

9 Describe how the rate of emission of radiation depends on the surface temperature and surface area of an object

2.3.4 Consequences of thermal energy transfer

Core

1 Explain some of the basic everyday applications and consequences of conduction, convection and radiation, including:

(a) heating objects such as kitchen pans

(b) heating a room by convection

Supplement

2 Explain some of the complex applications and consequences of conduction, convection and radiation where more than one type of thermal energy transfer is significant, including:

(a) a fire burning wood or coal

(b) a radiator in a car

11.1 Thermal energy transfer

When does thermal energy happen? How does it happen?

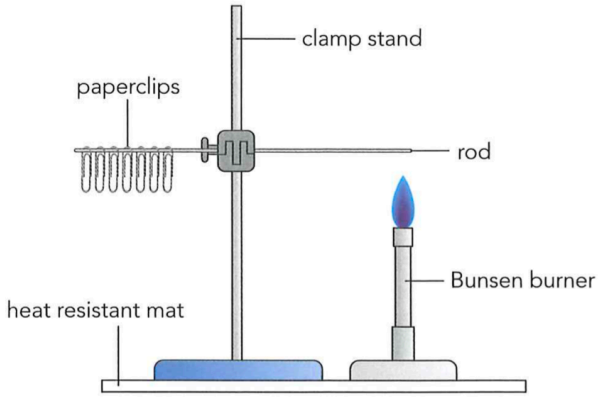
11.2 Conduction

Pick up a metal and a wooden spoon in turn, do you feel any difference?

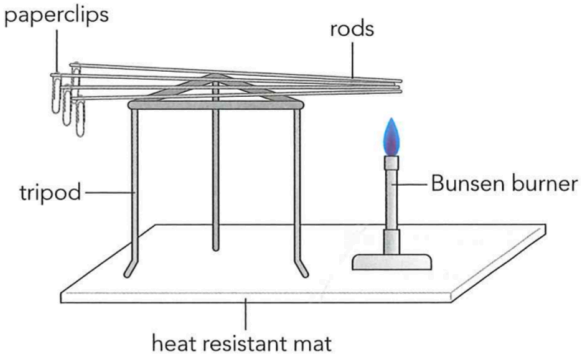
Thermal conductor vs thermal insulator

Experiment: Investigate conductors and insulators

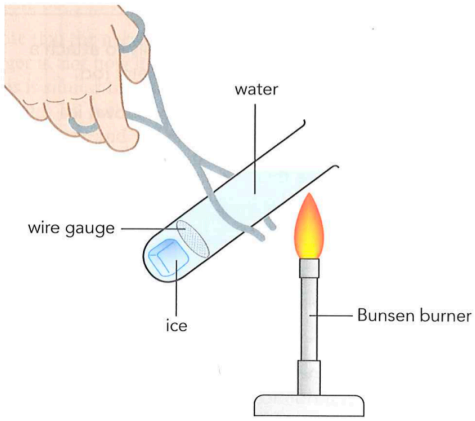
a. How is thermal energy conducted along a metal bar?



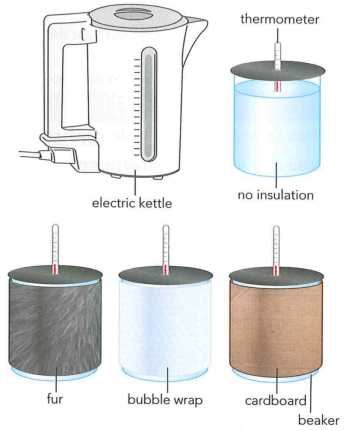
b. Which metal is the best conductor?



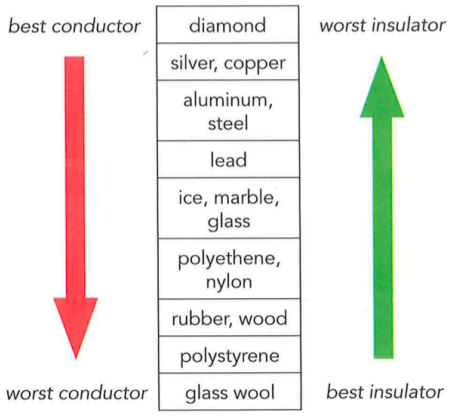
c. Is water a good conductor of thermal energy?



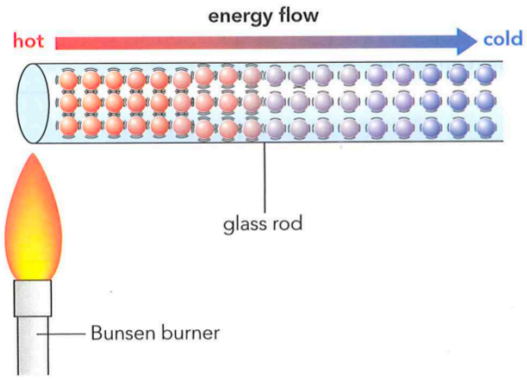
d. What materials make good insulators?

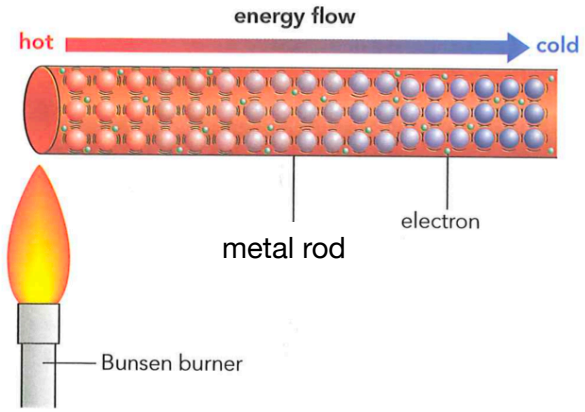


In general,



Explaining conduction:

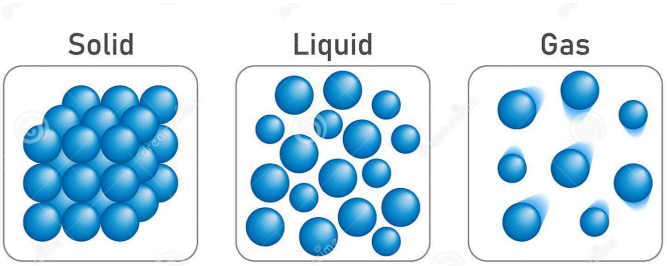




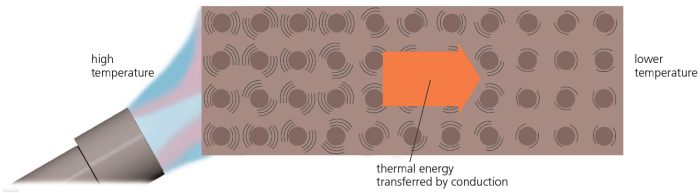
Non-metal:

Metal:
(main)
(minor)

Fluid:



How to get greater conduction rate?



Conduction in real life:

Exercise 11.1

Conduction happens mostly in {solids/liquids/gases}. Thermal energy flows from the {hotter/ cooler} parts of an object to the {hotter/cooler} parts. A material which does not conduct thermal energy well is called {a conductor/ an insulator/ a resistor}. An example is {copper/ polystyrene/ gold}.

Exercise 11.2

Explain why a wooden spoon is better than a metal one to stir a saucepan of hot soup.

Exercise 11.3

Explain why two thin layers of clothing are often warmer than one thick layer.

Exercise 11.4

Explain why:
a. Copper is a better conductor than wood
b. Wood is a better conductor than air.

11.3 Convection

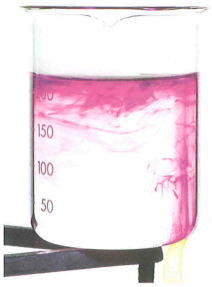
Convection: transfer of thermal energy through a material by **the movement of the material** itself

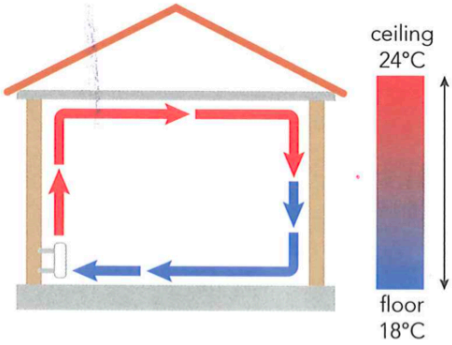
Explanation：

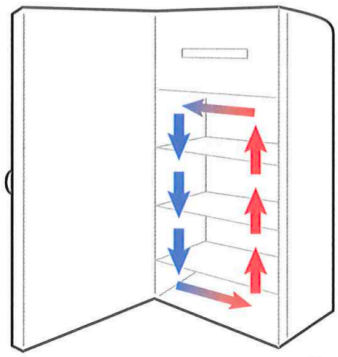
Convection only happens in _____

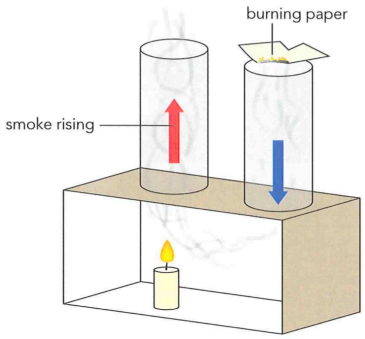
Convection current:

What do convection current do?









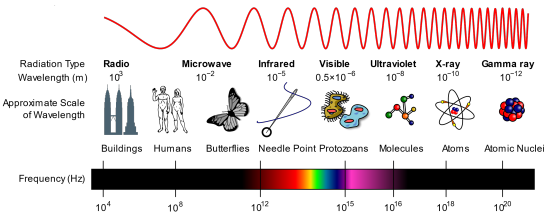
Exercise 11.5

An inventor makes an electric kettle with the heating element at the top. Explain why it will not work.

Exercise 11.6

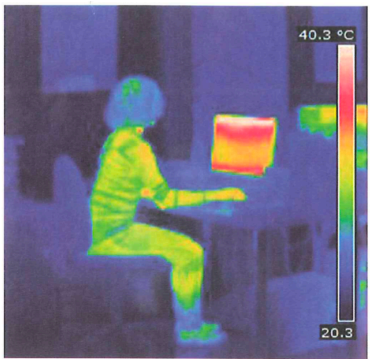
Explain why convection does not happen in solids.

11.4 Radiation



Infrared radiation:

1. Is a form of EM, invisible to the naked eye
2. **Produced by warm or hot objects**
3. **Warms the objects that absorbs it**
4. Can travels through empty space and medium
   Only form of thermal energy transfer that doesn't involve the motion of particles
5. Travel in straight line
6. Can be detected by nerve cells in the skin (close to a thermal source)

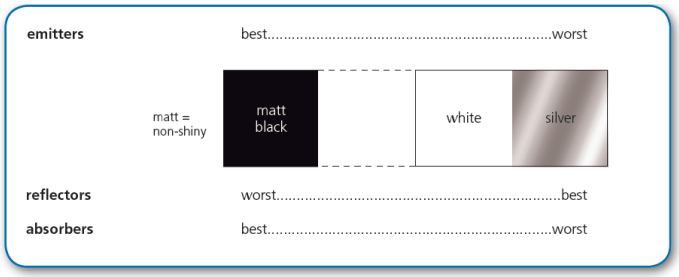


Exercise 11.7

Explain why thermal energy from the Sun can only reach us by radiation, not conduction or convection.

Exercise 11.8

Which statement about infrared radiation is true?
a. Infrared radiation travels slower than light
b. Infrared radiation cannot be reflected
c. Infrared radiation can travel through a vacuum
d. Infrared radiation is transferred by the movement of particles



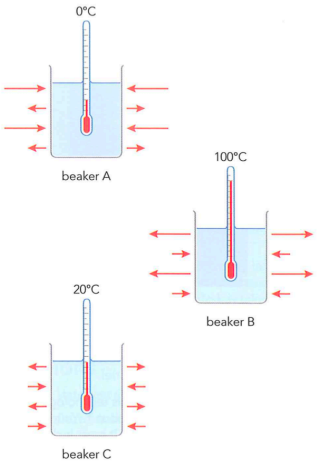
Good absorbers, good emitters

It's the _____ that determines whether an object absorbs or reflects infrared radiation.

Good absorbers:
Good emitters:
Good reflectors:

Exercise 11.9

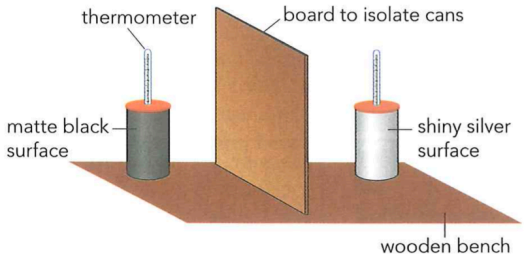
Which will stay hot longer: tea in a shiny silver teapot or tea in dark brown one? Explain why.

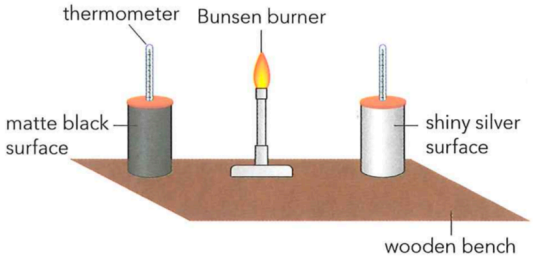


Factors affecting infrared radiation

Surface temperature
Surface area
Surface texture

Experiment: good emitters & good absorbers



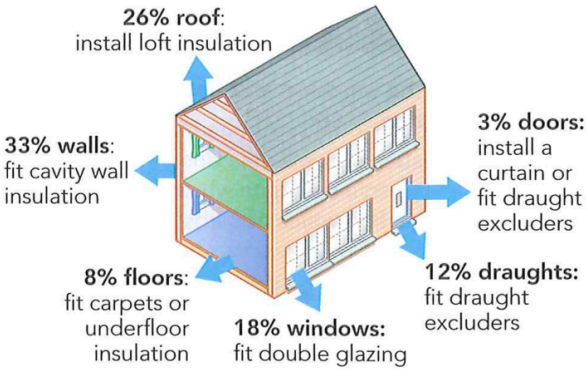


Conduction	
Convection	
Radiation	

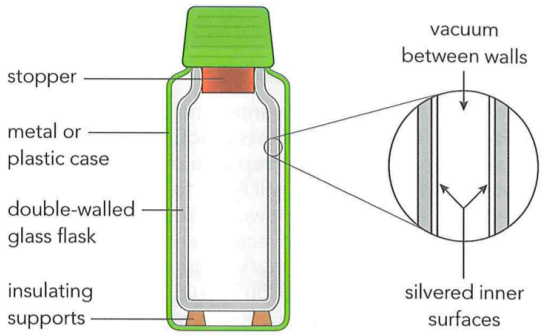
11.5 Consequences of thermal energy transfer

11.5.1
Energy keeps transfer from high temperature to low temperature => to keep warm/cool, need **<u>insulation</u>**

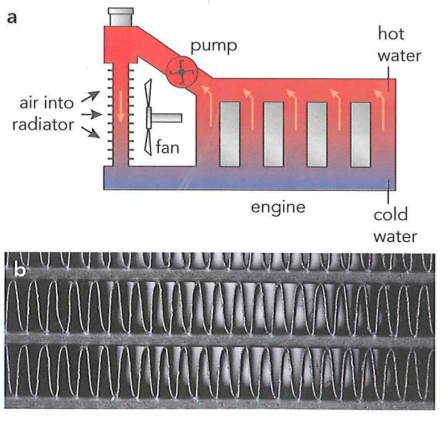
Home insulation



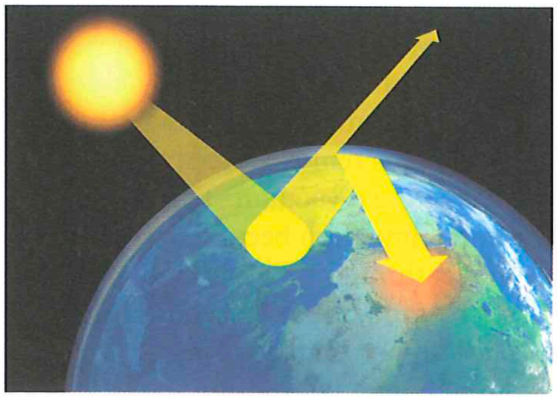
Vacuum flasks

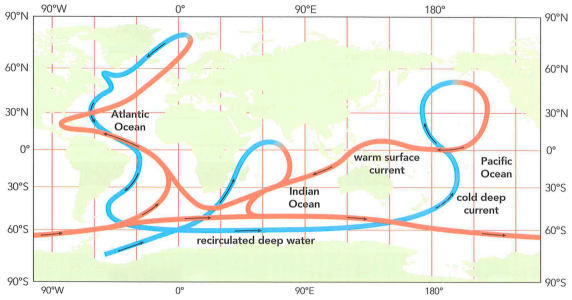


Radiator in a car



11.5.2 Thermal energy transfer: climate and weather





Exercise 11.10

In a rolling mill, iron is heated to make it malleable and it is then passed through rollers to produce thin sheets of the metal. Explain how the following become hot in this process.
The roller which press the metal
The face of a worker
The air in the building

Exercise 11.11

Pictures on the left shows a solar water heater. Cold water flows through the pipes and is heated by the sun. Suggest reasons why:
The inside of the panel is painted black
The back of the panel is insulated
The cold water enters at the bottom of the panel, and leaves at the top