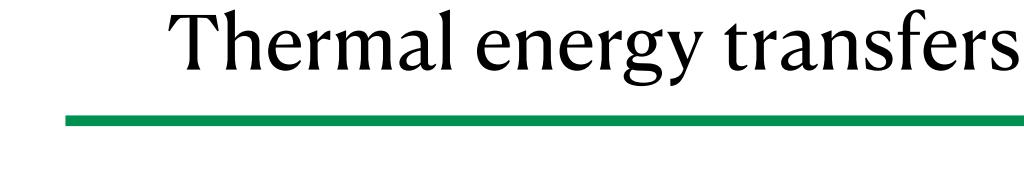


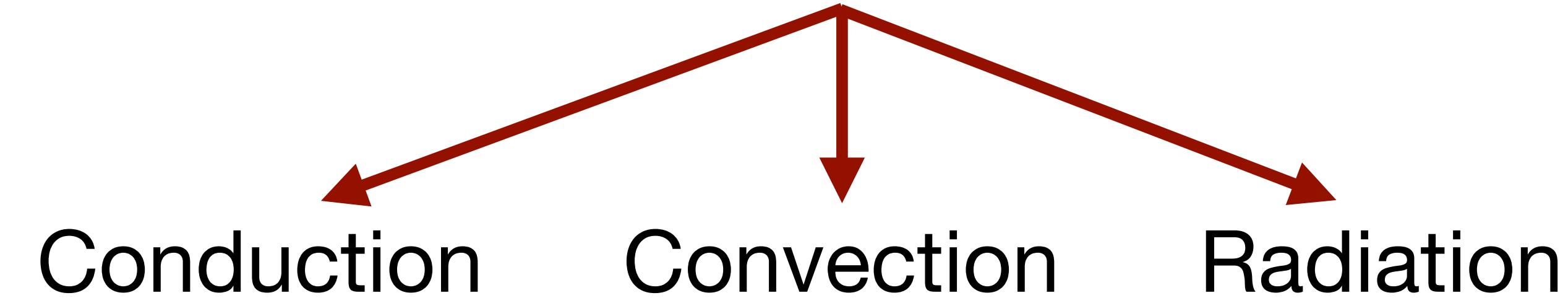
Thermal Energy Transfers

Ji Yutong, 08/2022

Thermal Energy Transfer

→ Higher temperature  Thermal energy transfers  Lower temperature

→ So, temperature difference → thermal energy transfer



Conduction

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



Conduction

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



Note: the nerves in your finger tell you how hot your finger is, not how hot the object your touch is.

Conduction

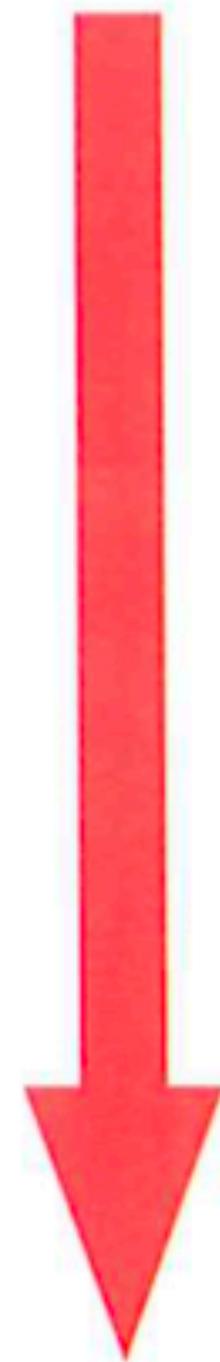
Thermal conductor

Thermal insulator

Note that, a good thermal conductor -> a bad thermal insulator
Binary opposition (二元对立) , e.g. 最亮的, 最不暗的

Good /bad conductors

best conductor



worst conductor

diamond
silver, copper
aluminum, steel
lead
ice, marble, glass
Polyethene, nylon
rubber, wood
polystyrene
glass wool

worst insulator



best insulator

Conduction

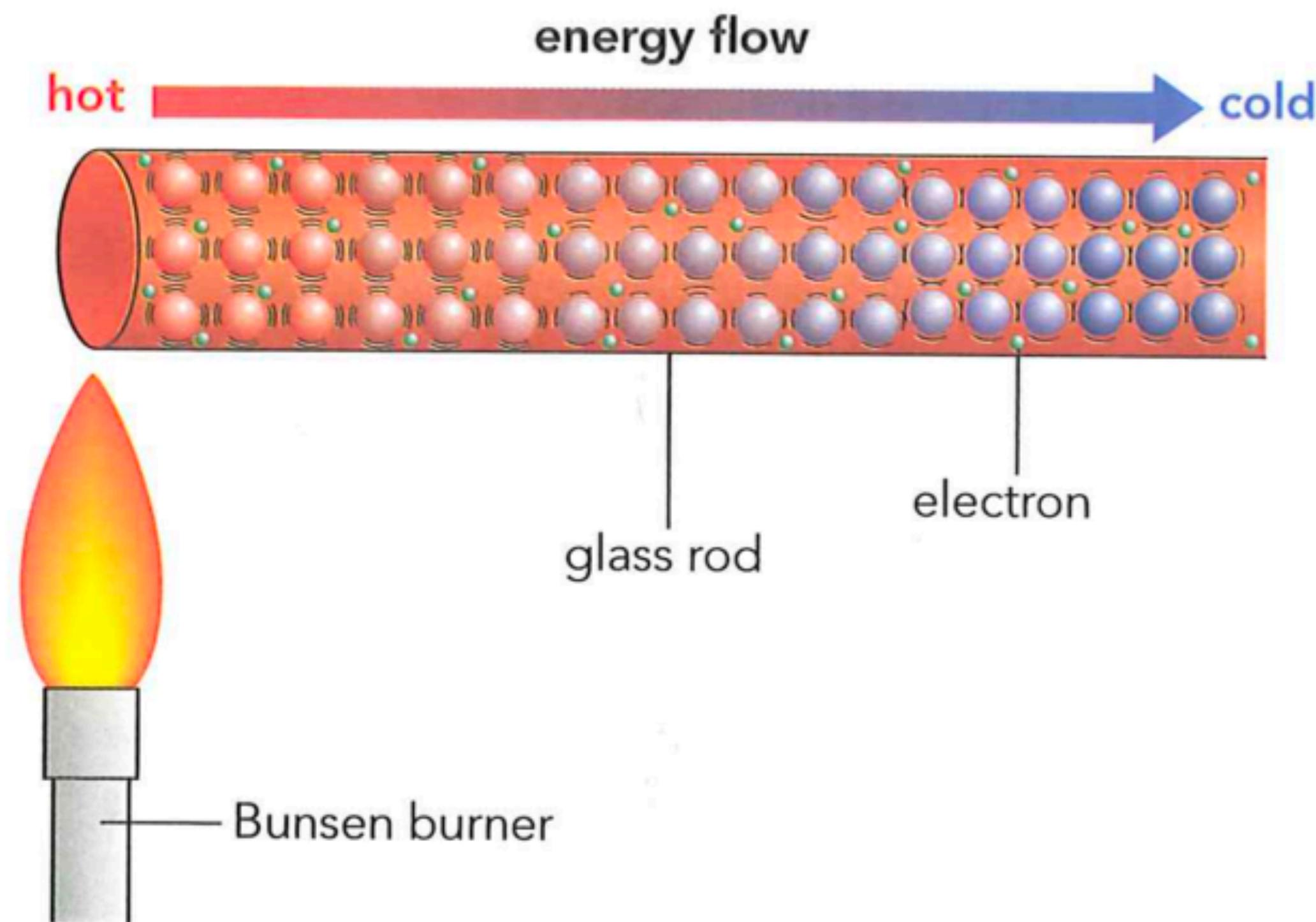
- Which of the following are good conductors?

- A. polyethylene 聚乙烯
- B. copper
- C. iron
- D. rubber
- E. silicon
- F. glass
- G. water
- H. aluminium
- I. wood
- J. glass wool 玻璃棉
- K. polystyrene 聚苯乙烯 (热塑塑料)



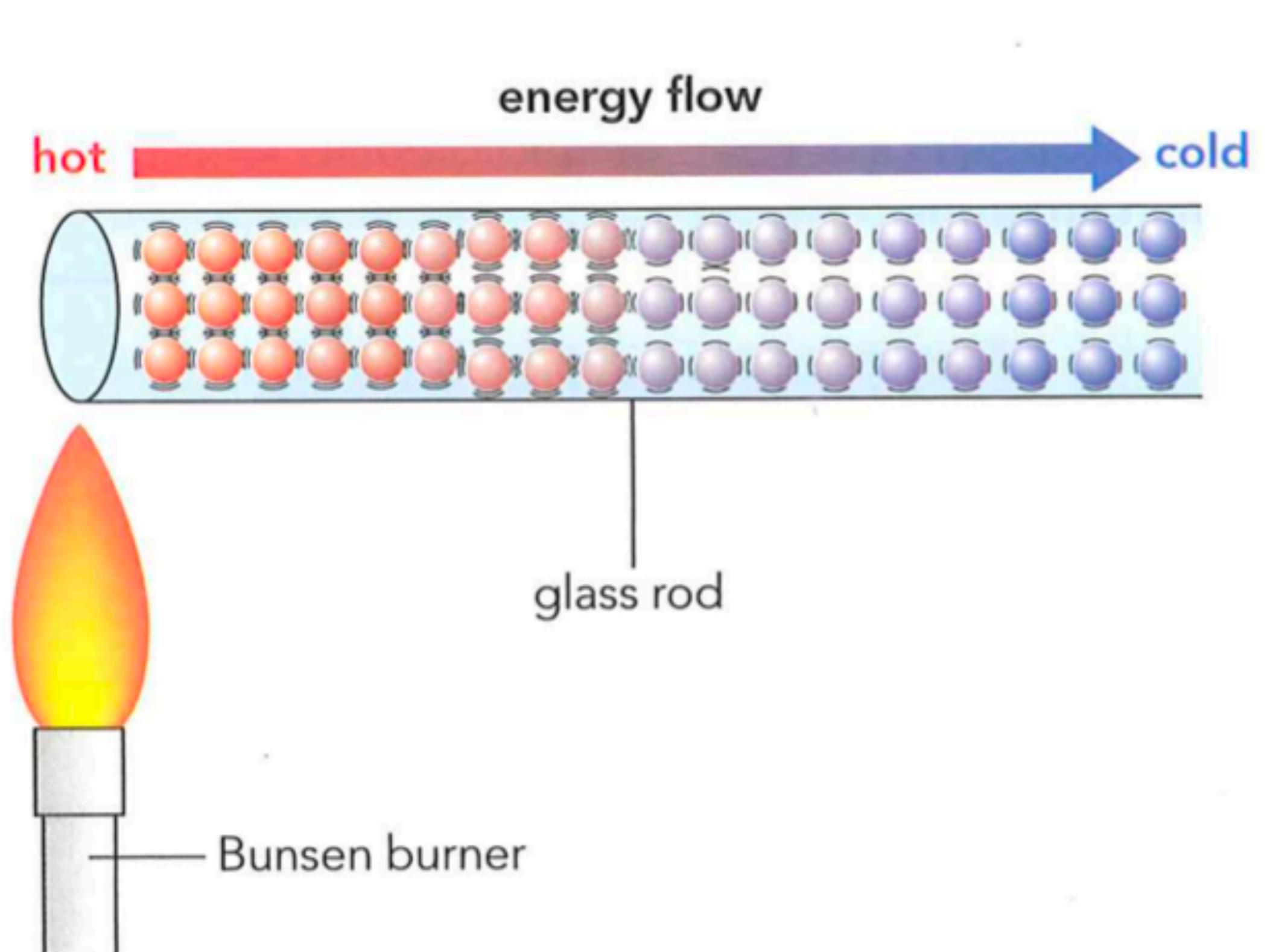
Explaining conduction

- Metal



Explain conduction

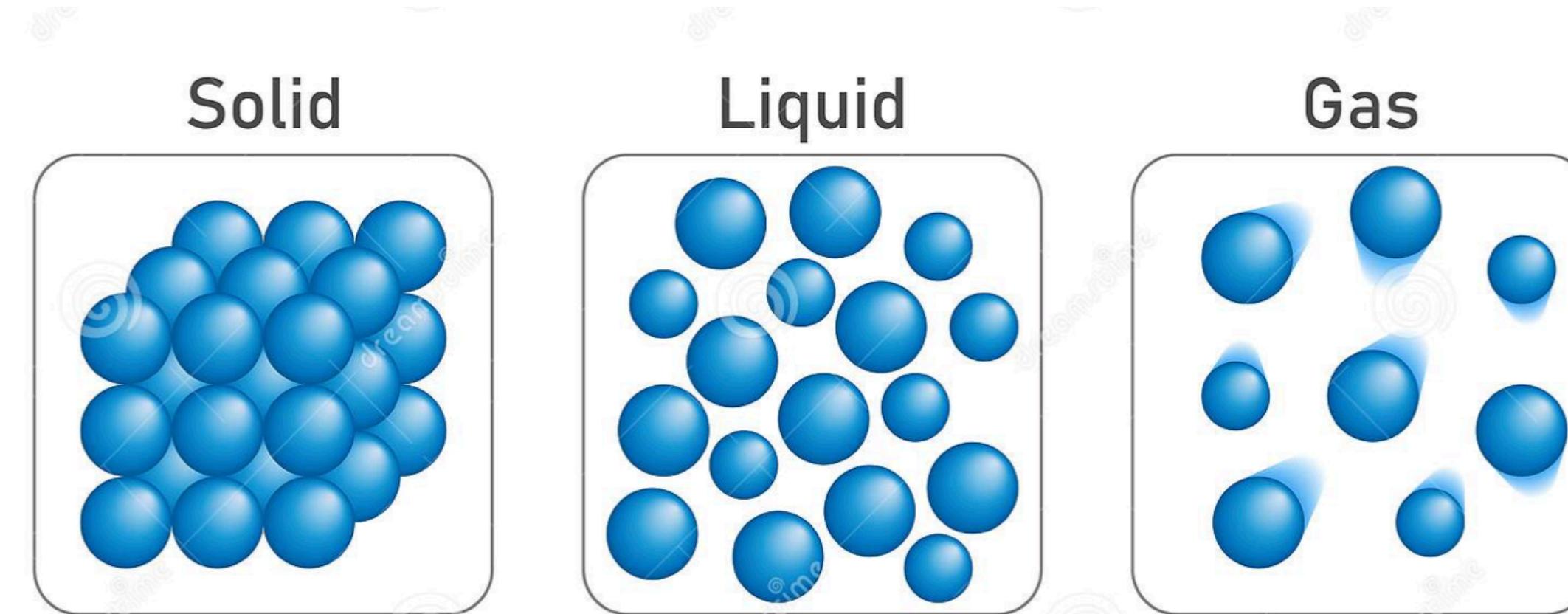
- Non-metal



Explain conduction

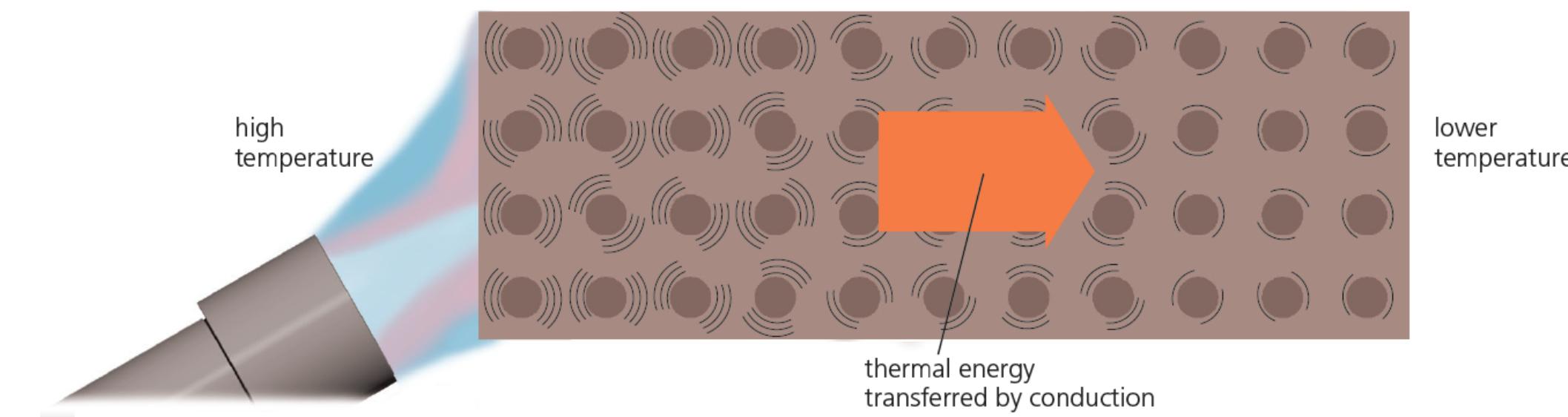
Fluid (liquid + gas)

Particles free to move -> vibrations not easily past -> bad conductors



Conduction

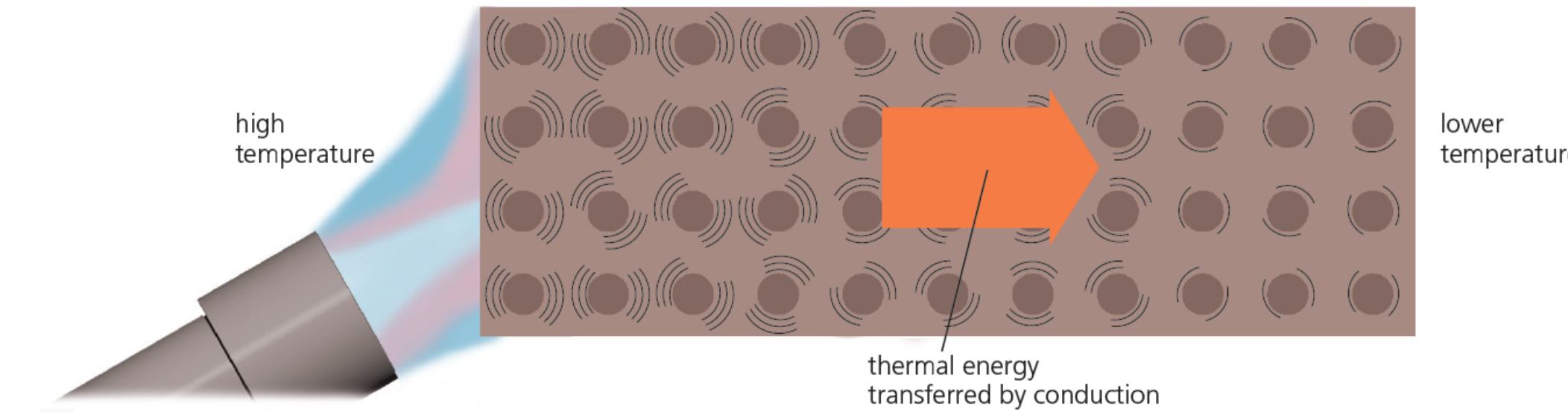
- Conduction is the most significant heat transfer in solids.
- How to get greater conduction rate?



Conduction

Greater rate of conduction if...

- The temperature difference across the ends of the bar is increased
- The cross-sectional ('end-on') area of the bar is increased
- The length of the bar is reduced



Questions

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

Questions

3. Use the information in Table 11.1 to explain why walking on a marble floor in bare feet would feel colder than walking on a wooden floor.
4. Explain why two thin layers of clothing are often warmer than one thick layer.
5. Explain why:
 - a. Copper is a better conductor than wood
 - b. Wood is a better conductor than air.

Questions

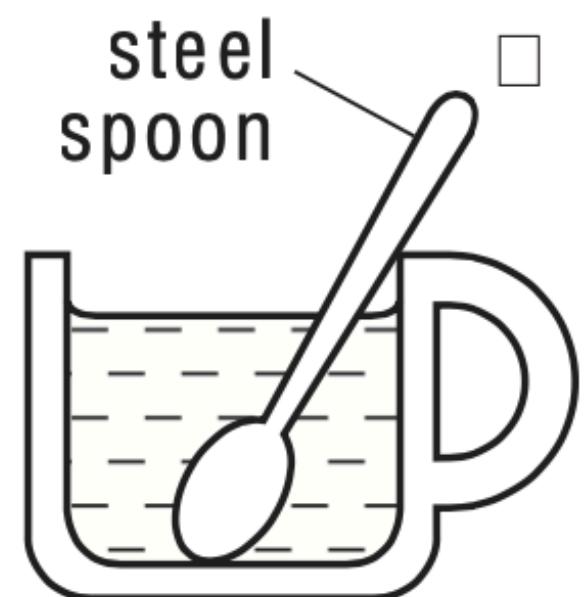
Spoons made of different materials were placed in four cups of coffee poured from the same jug.

Which spoon will be hottest to touch at end X?

experiment A



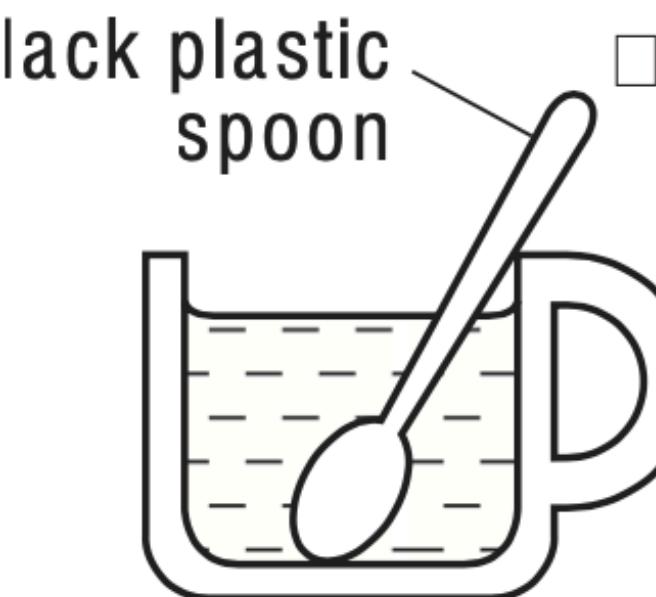
experiment B



experiment C



experiment D



Summary

- Temperature difference -> thermal transfer
- Conduction is a type of thermal transfer
- Conduction is most significant in solids.
- **Conduction ability: metal > non-metal > fluid. This is due to their different micro-structure.**

Convection

Happens in all fluids(liquid/gas), not in solid



hot air rises

Convection

- Convection current : a movement of a fluid that carries energy from a warmer place to a cooler one
- Key difference: Convection vs conduction

Convection in water

- How is heat being transferred in this picture?
- How is convection current moves in it?



Convection in water

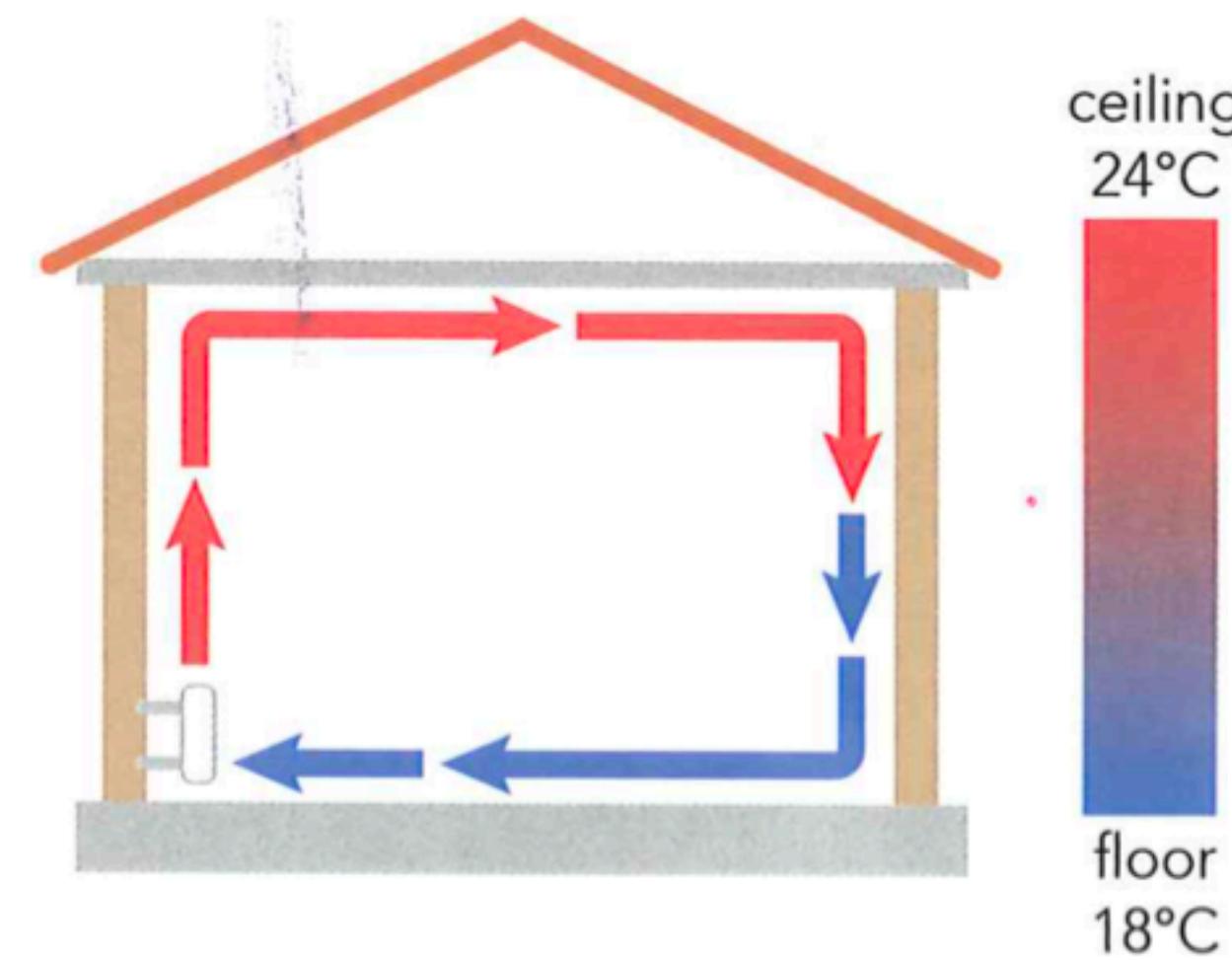
- Can you explain this picture?



Convection current at work

- What do convection current do? Share energy between warm and cold places

- Heater in the room



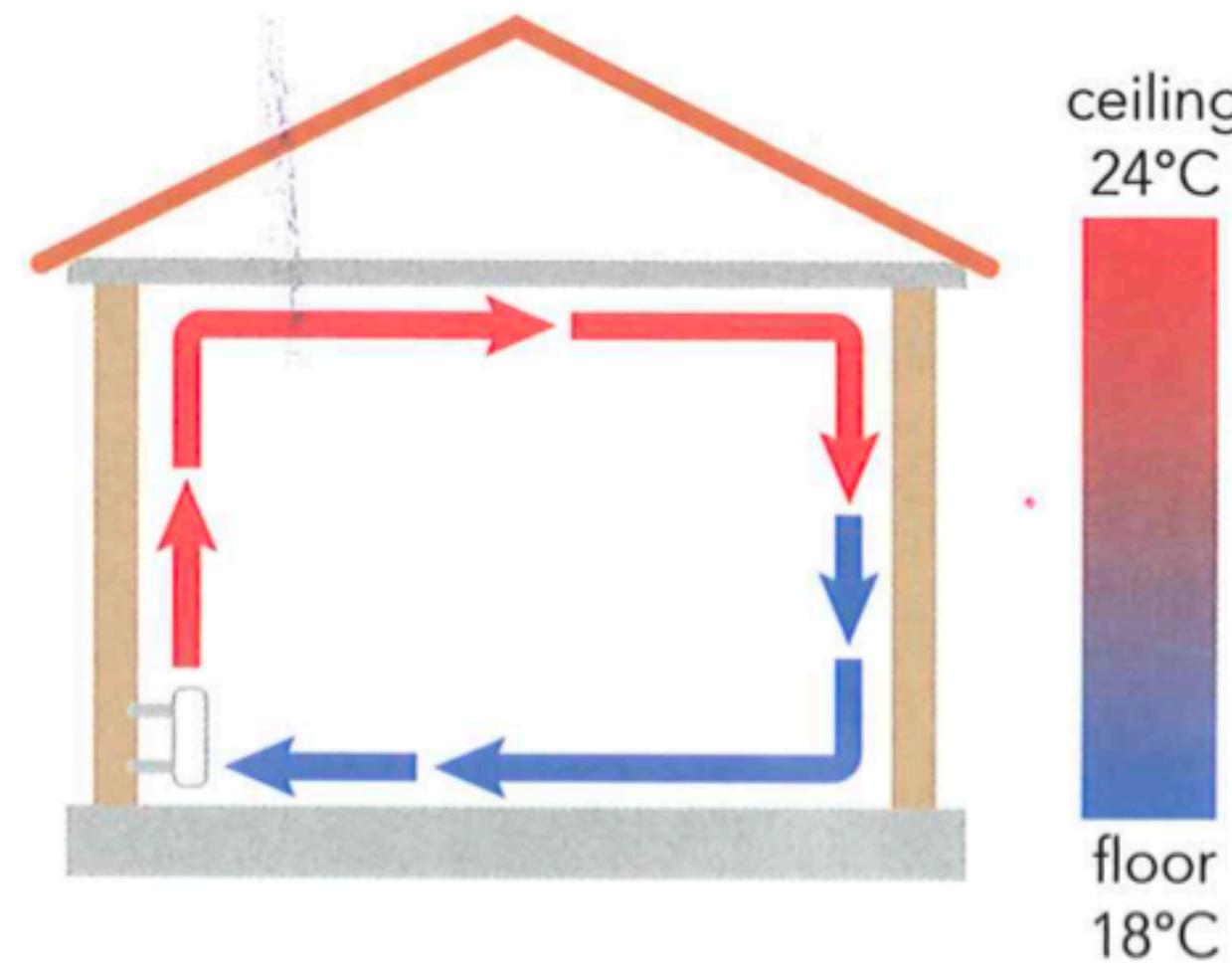
- Refrigerator: where is the freezing surface



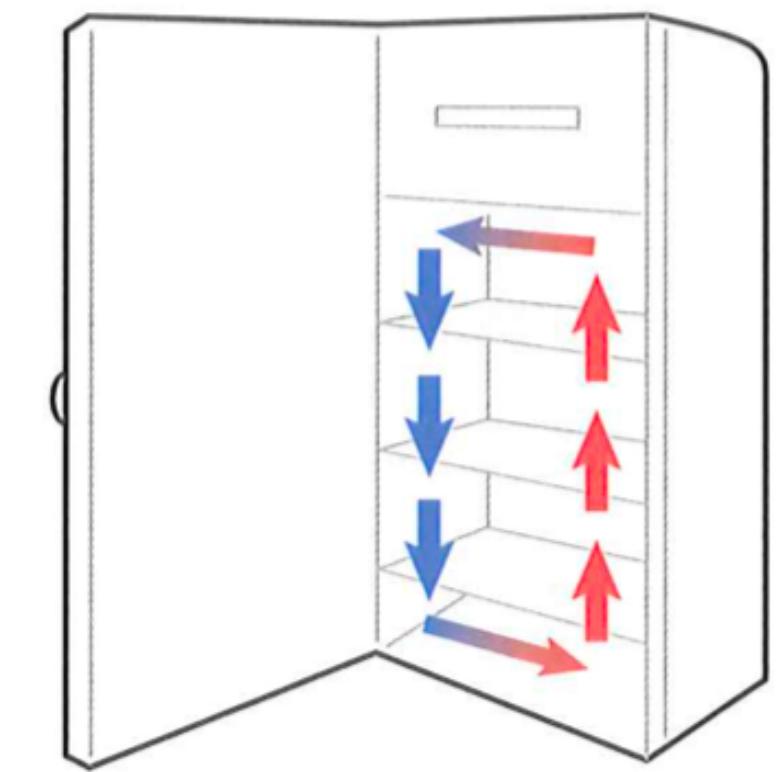
Convection current at work

- What do convection current do? Share energy between warm and cold places

- Heater in the room



- Refrigerator: where is the freezing surface



Questions

- 1. An inventor makes an electric kettle with the heating element at the top. Explain why it will not work.
- 2. Explain why convection does not happen in solids.

Questions

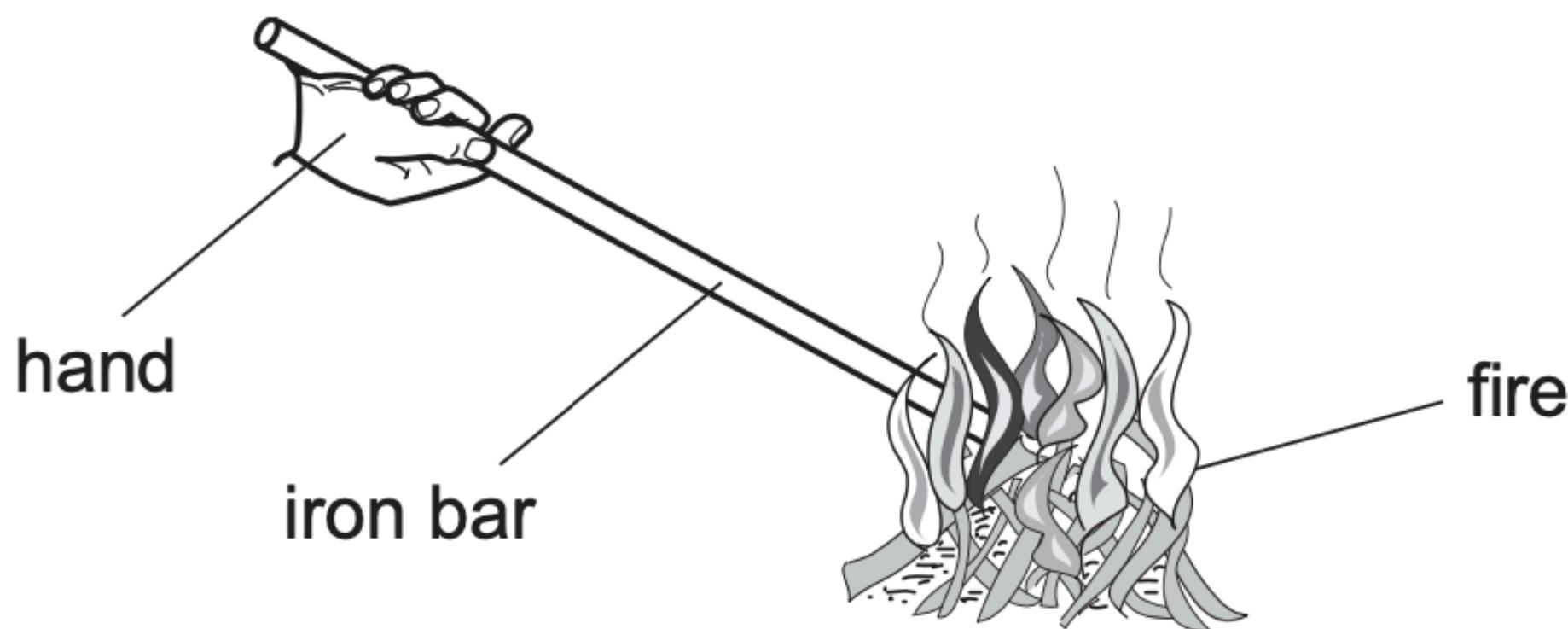
A person holds a glass beaker in one hand and fills it quickly with hot water. It takes several seconds before his hand starts to feel the heat.

Why is there this delay?

- A Glass is a poor conductor of heat.
- B Glass is a good conductor of heat.
- C Water is a poor conductor of heat.
- D Water is a good conductor of heat.

Questions

An iron bar is held with one end in a fire. The other end soon becomes too hot to hold.



How has the heat travelled along the iron bar?

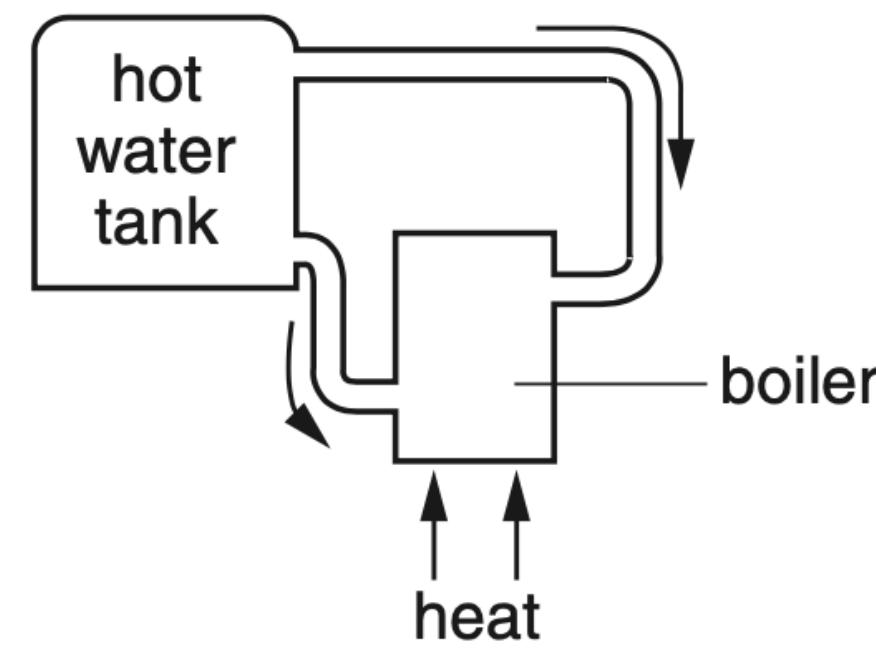
- A by conduction
- B by convection
- C by expansion
- D by radiation

Questions

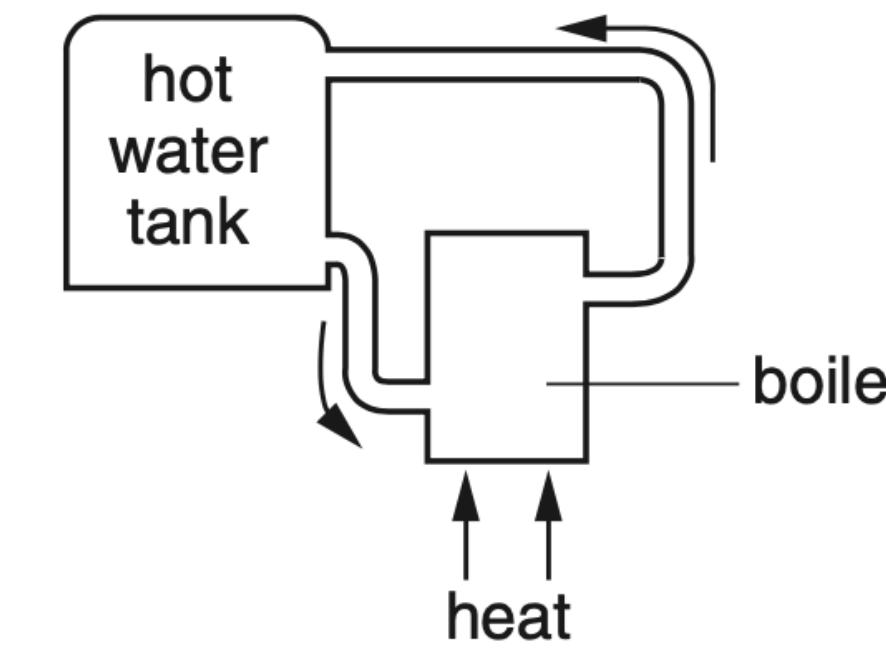
The diagrams show part of a water-heating system which is working by convection.

Which diagram shows the most likely flow of water in the system?

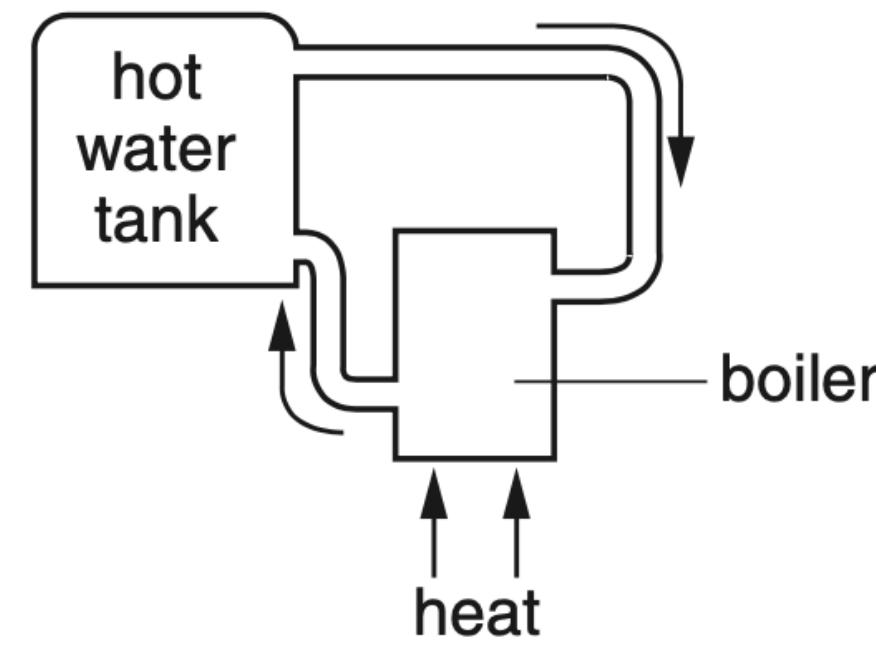
A



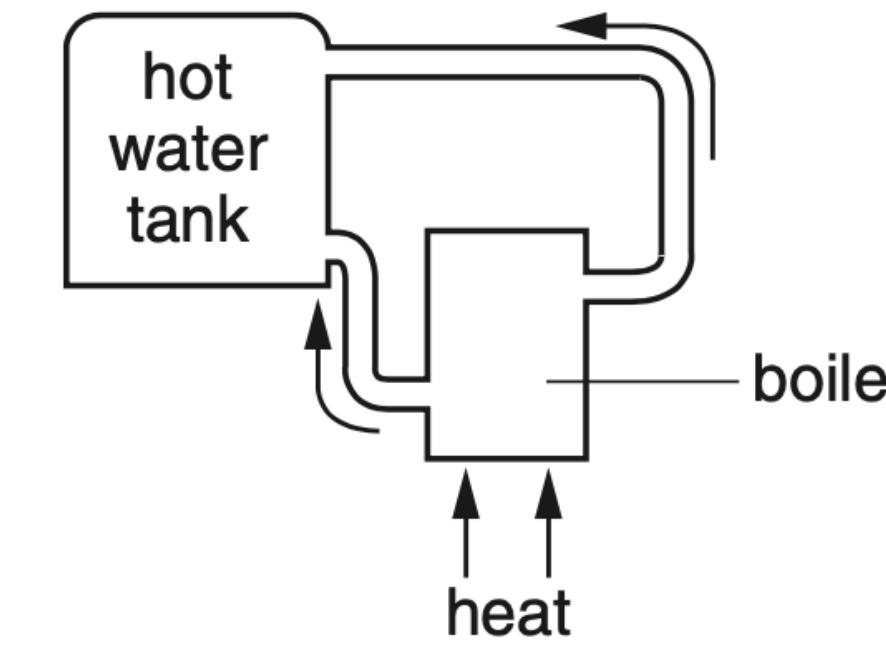
B



C



D



Summary

- Convection is a type of thermal transfer, but only happens in fluids.
- Convection current
- Convection vs conduction

Radiation

- Do you see further during the daytime or at night?

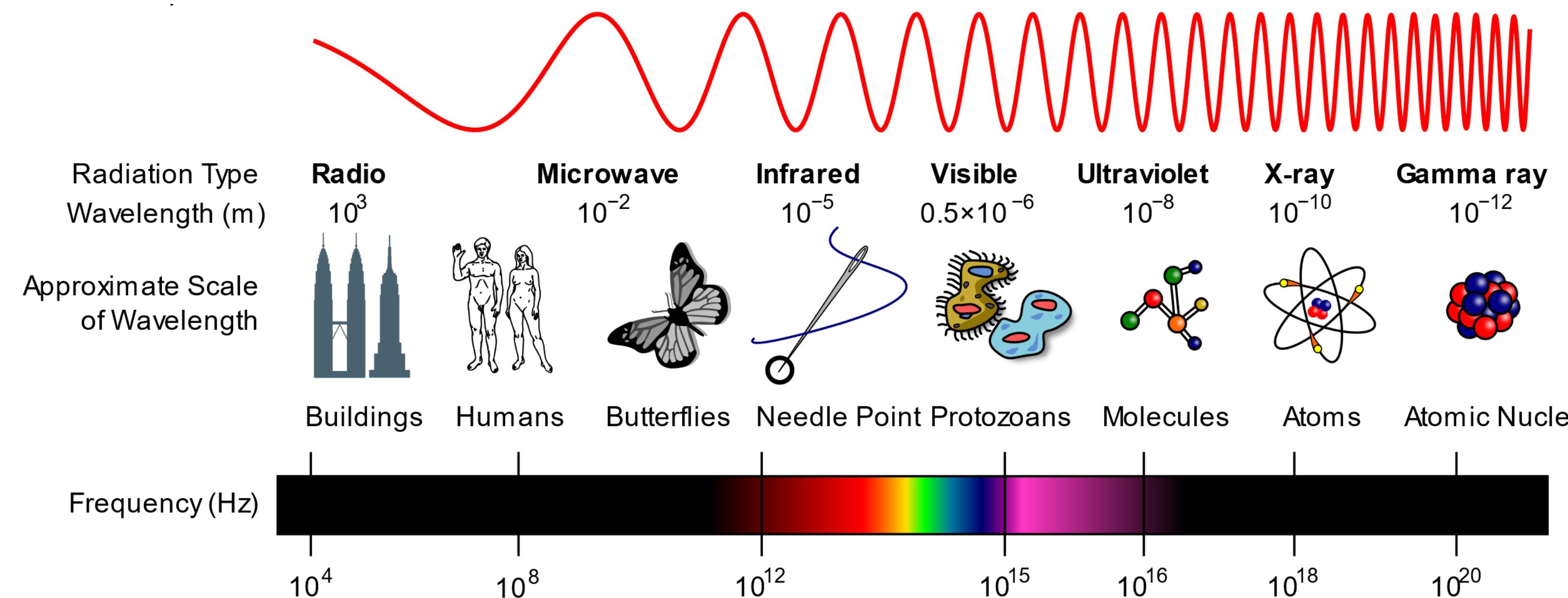
Radiation

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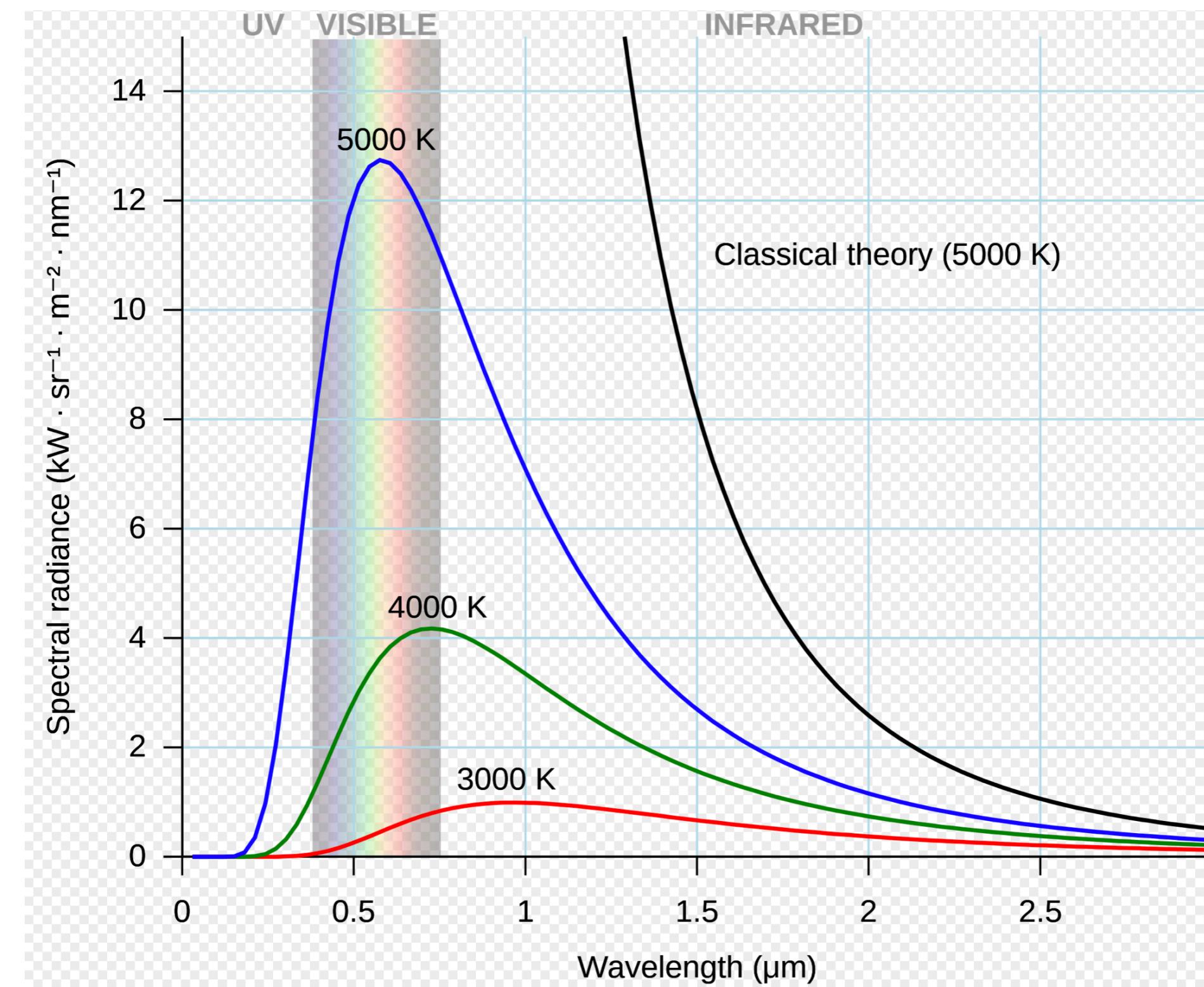
Radiation

- Heat can travel on a wave, Electromagnetic Wave(EM wave).
- EM wave:
 1. Can travel through a vacuum (Sun -> Earth)
 2. In vacuum, $v = \text{speed of light}$



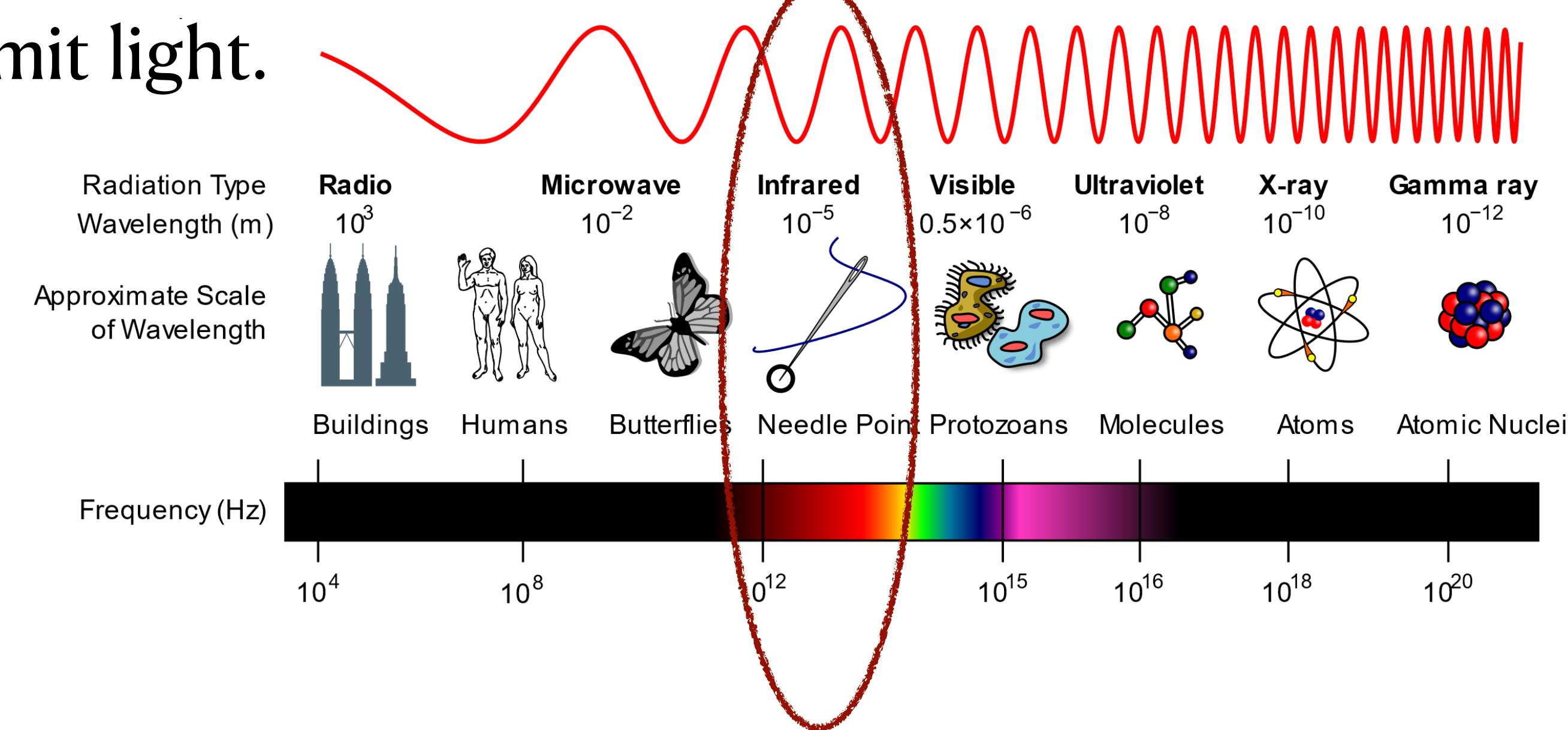
Infrared radiation

- All objects emit electromagnetic radiation – for warm object infrared radiation is most dominant
- Infrared radiation/ thermal(energy) radiation



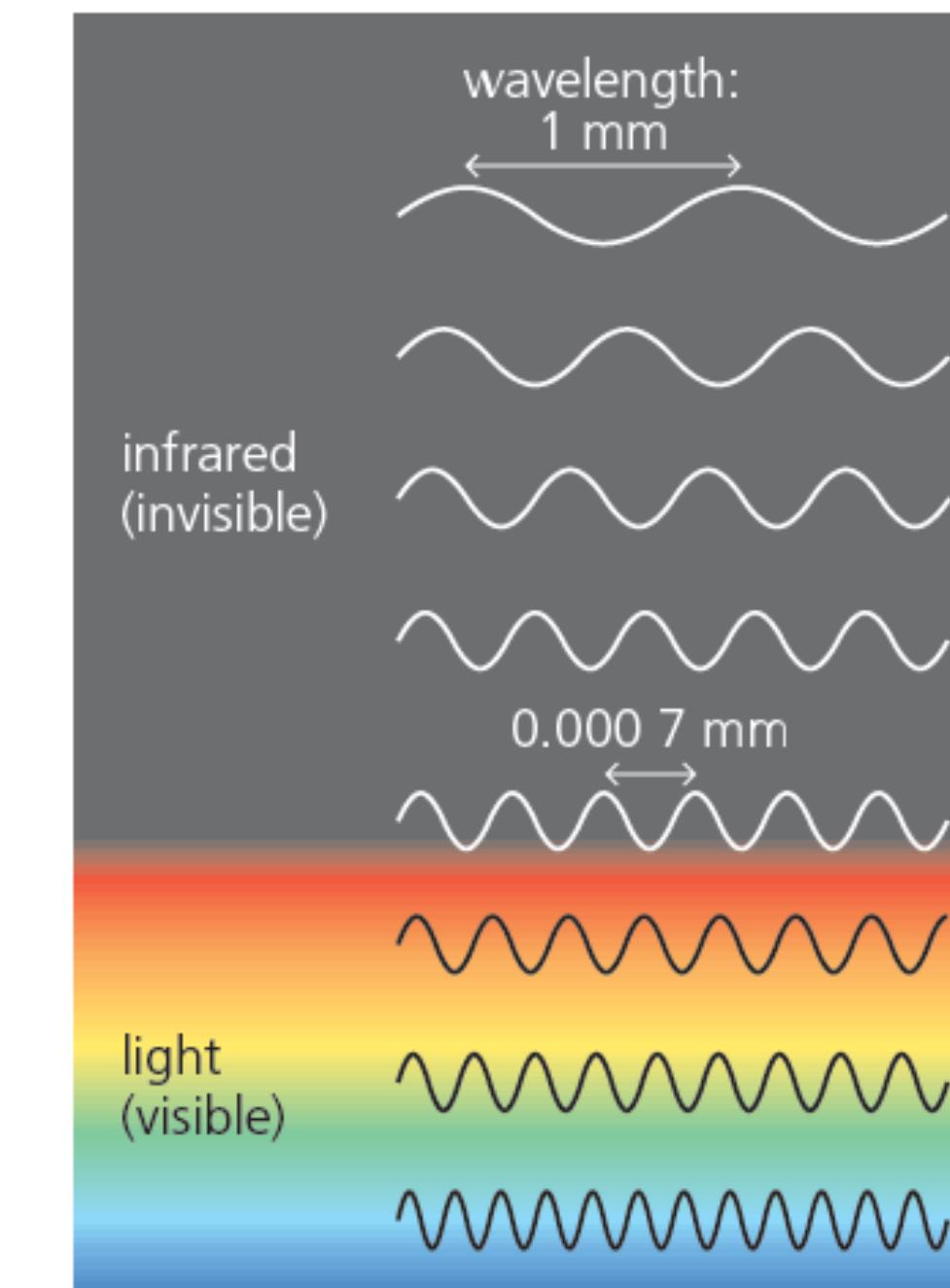
Infrared radiation

- All objects emit electromagnetic radiation – for warm object infrared radiation is most dominant
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 - 1. Higher T → more radiation energy
 - 2. Very hot objects may emit light.



Infrared radiation

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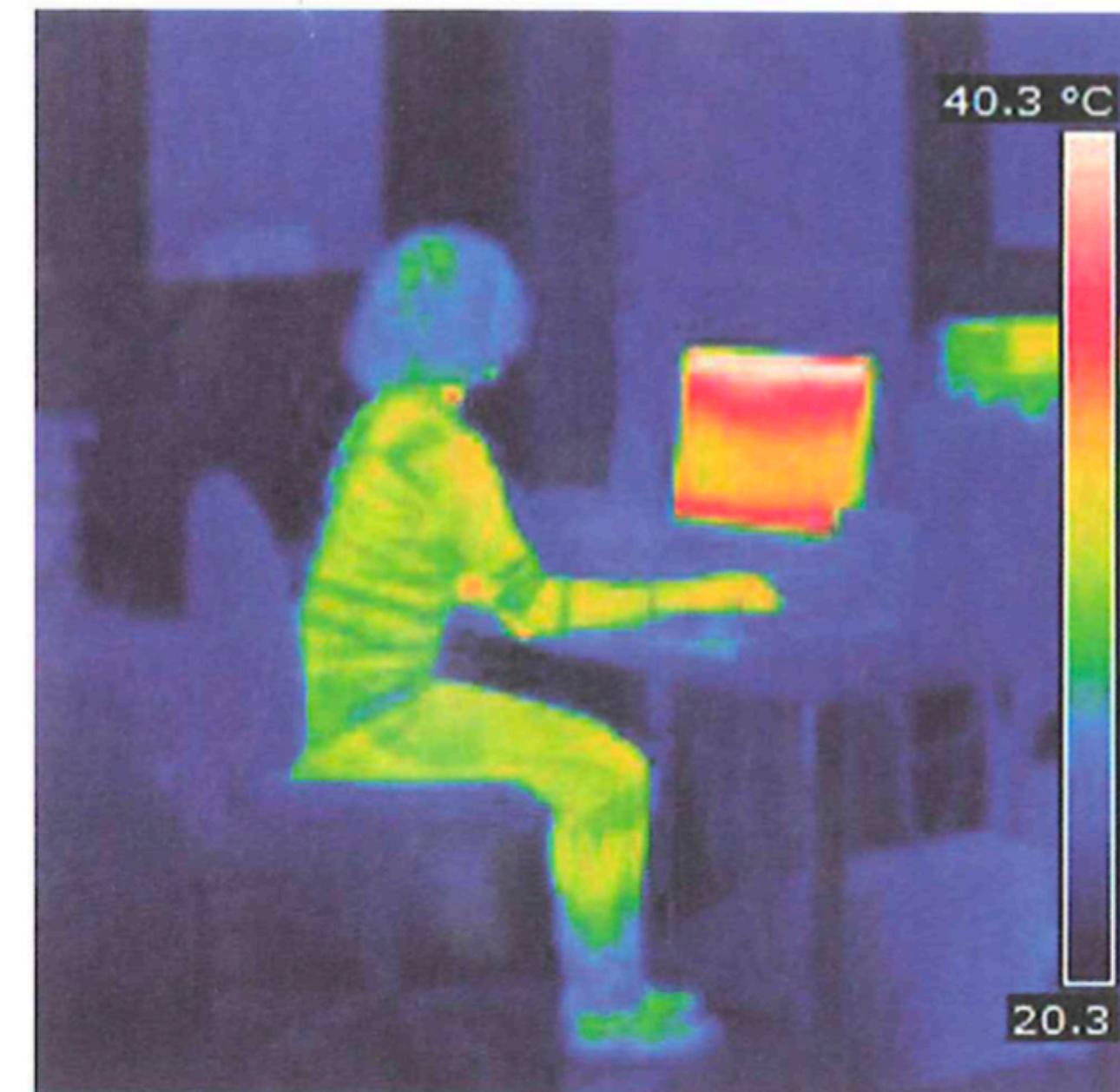
Infrared radiation

- All objects emit electromagnetic radiation – for warm object infrared radiation is most dominant
- Infrared radiation/ thermal(energy) radiation
 1. Higher T -> more radiation energy
 2. Very hot objects may emit light.
- Only form of thermal energy transfer that doesn't involve the motion of particles

Detecting Infrared radiation

1. Skin nerve cells

2. Temperature sensitive camera



Summary on infrared radiation

- Is produced by warm or hot objects ?
- Is a form of electromagnetic radiation
- Travels in straight line in flat space
- Warms the object that absorbs it
- Can be detected by nerve cells in the skin

Questions

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

Questions

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

Questions

- What evidence is there in this infrared photograph to suggest that the car has only just broken down?



Good absorbers, good emitters

→ Surface determines whether reflect/absorb

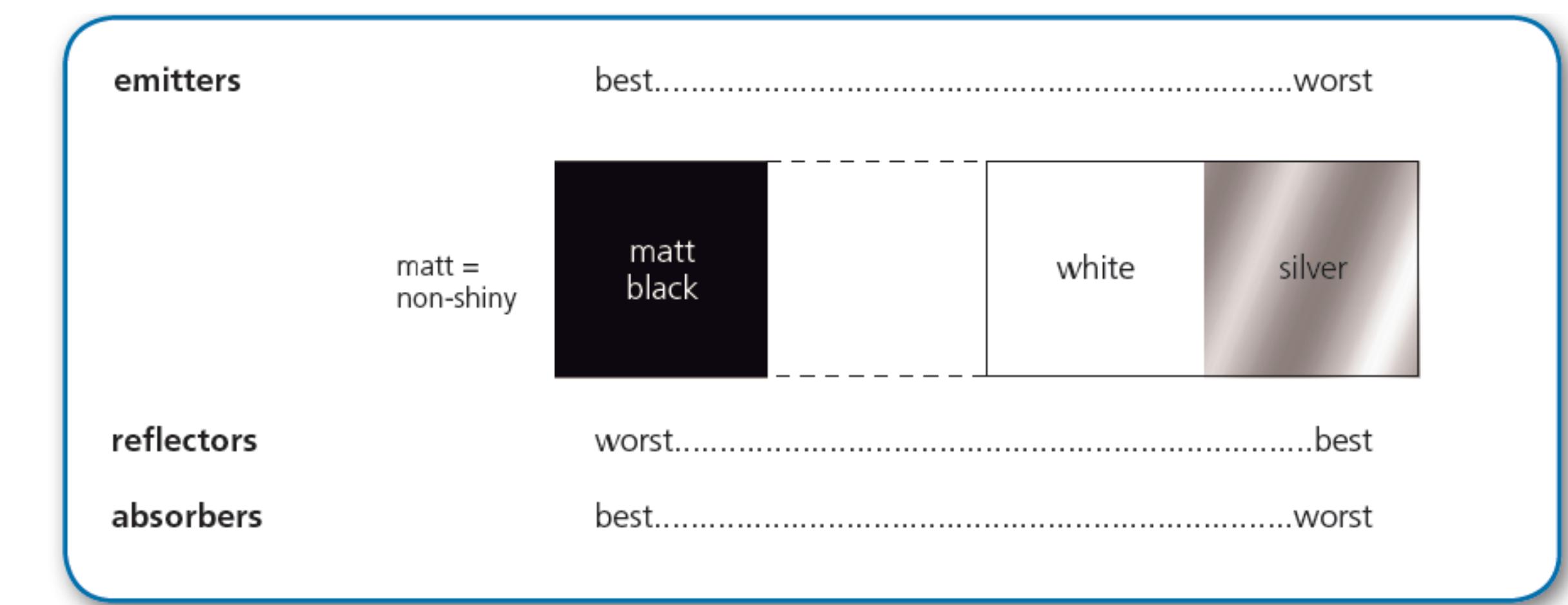
→ Some surfaces absorb heat better.

- Dark

Some surfaces reflect more heat.

- Light

Dark surfaces also emit heat faster.



Good absorbers, good emitters

- Shinny or white surface are the best reflectors (the worst absorbers)
- Matte black surface are the best absorbers(the worst reflectors)
- Matte black surface are the best emitters.



Can you explain why?

Solar panels

Some solar panels absorb heat to heat up water.

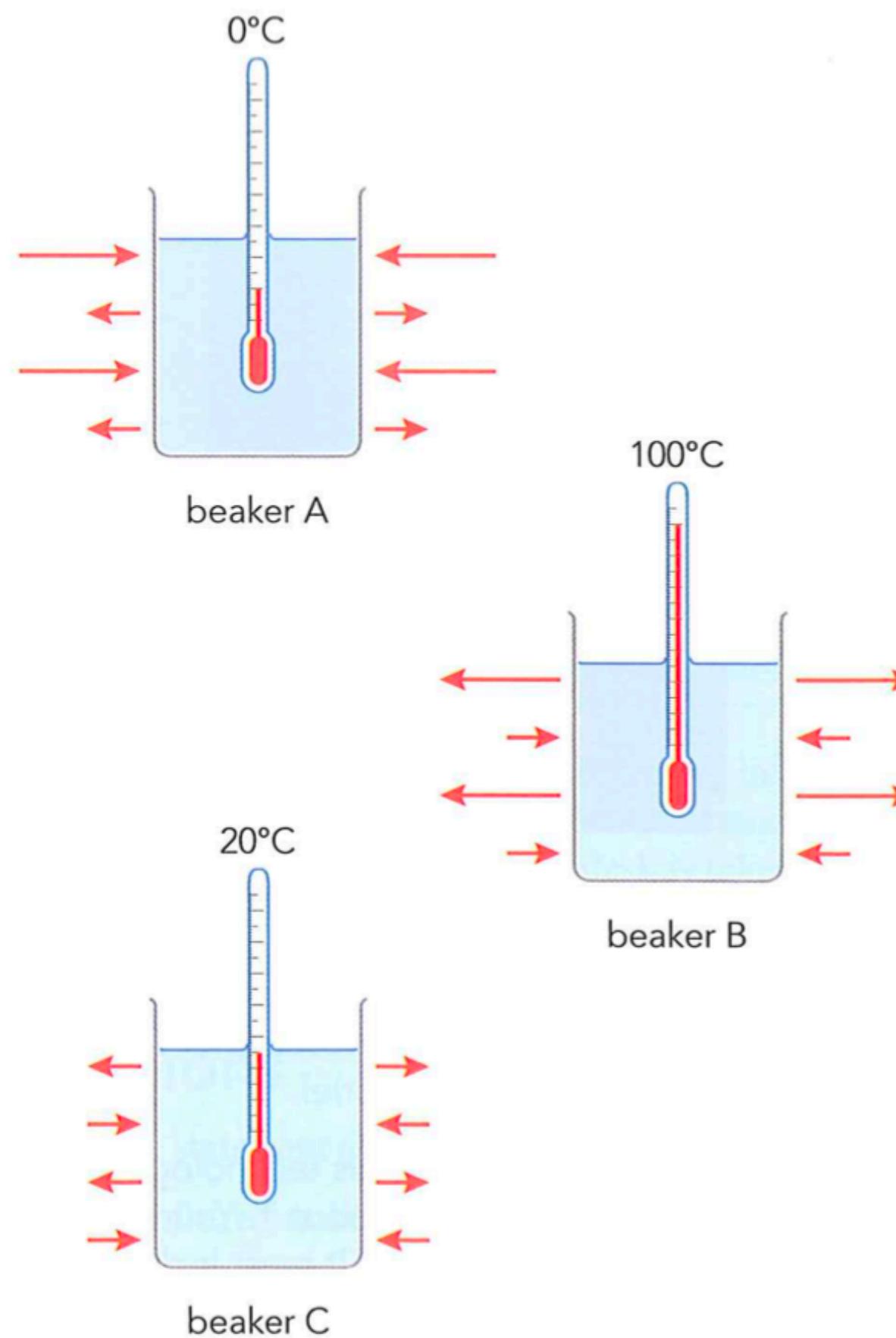
These panels should be dark.



Question

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

Factors affecting infrared radiation



Summary

- All objects emits infrared radiation. Warmer objects emits more.
- Infrared radiation is a type of EM radiation, so can travel in vacuum(doesn't need medium)
- Dark & dull surface vs light & shiny surface

Questions

There is a vacuum between the double walls of a vacuum flask.

Which types of heat transfer are reduced by the vacuum?

- A** conduction and convection
- B** conduction and radiation
- C** convection and radiation
- D** conduction, convection and radiation

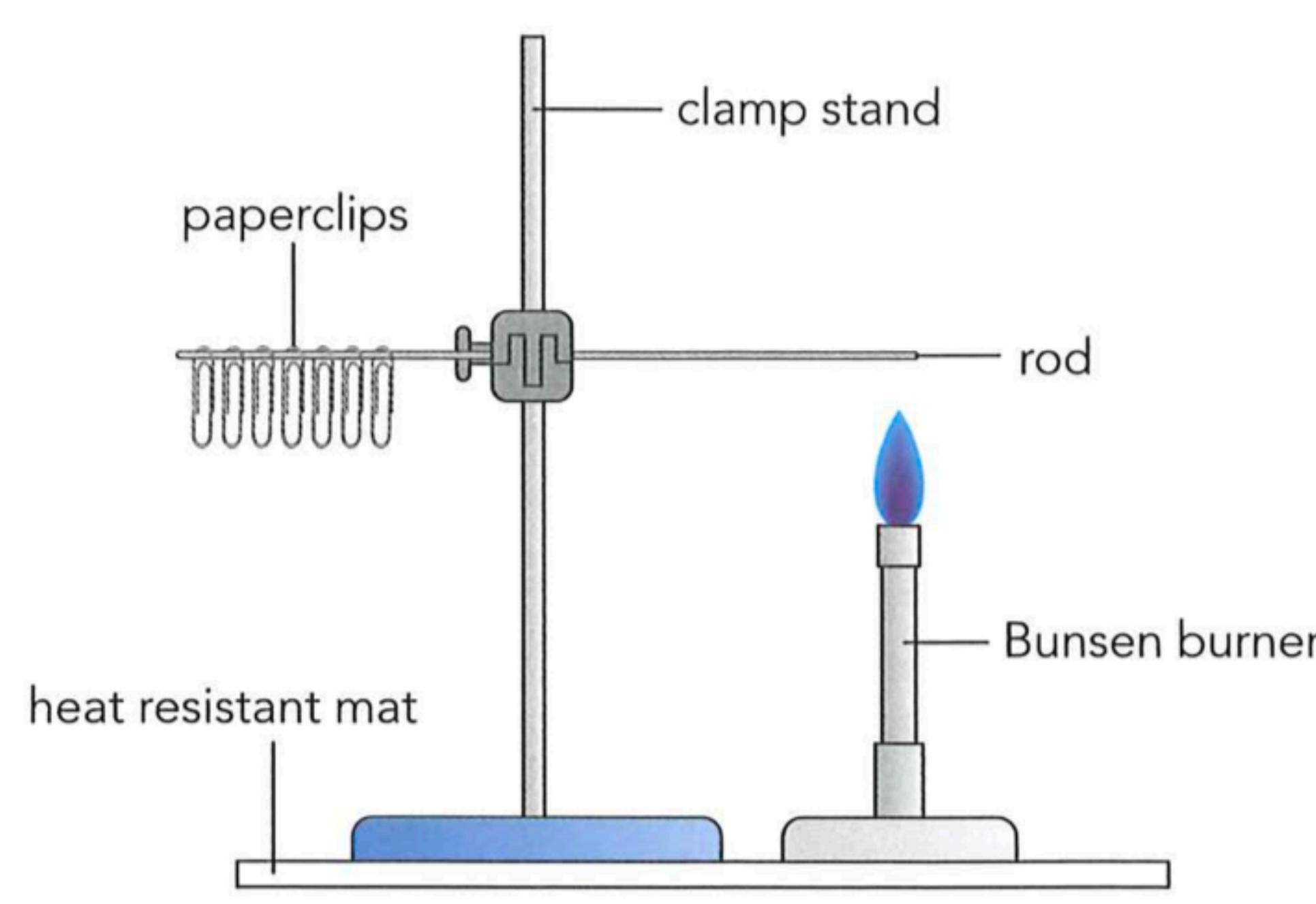
Questions

How does heat from the Sun reach the Earth?

- A** conduction only
- B** convection only
- C** radiation only
- D** conduction, convection and radiation

Conductivity Experiments

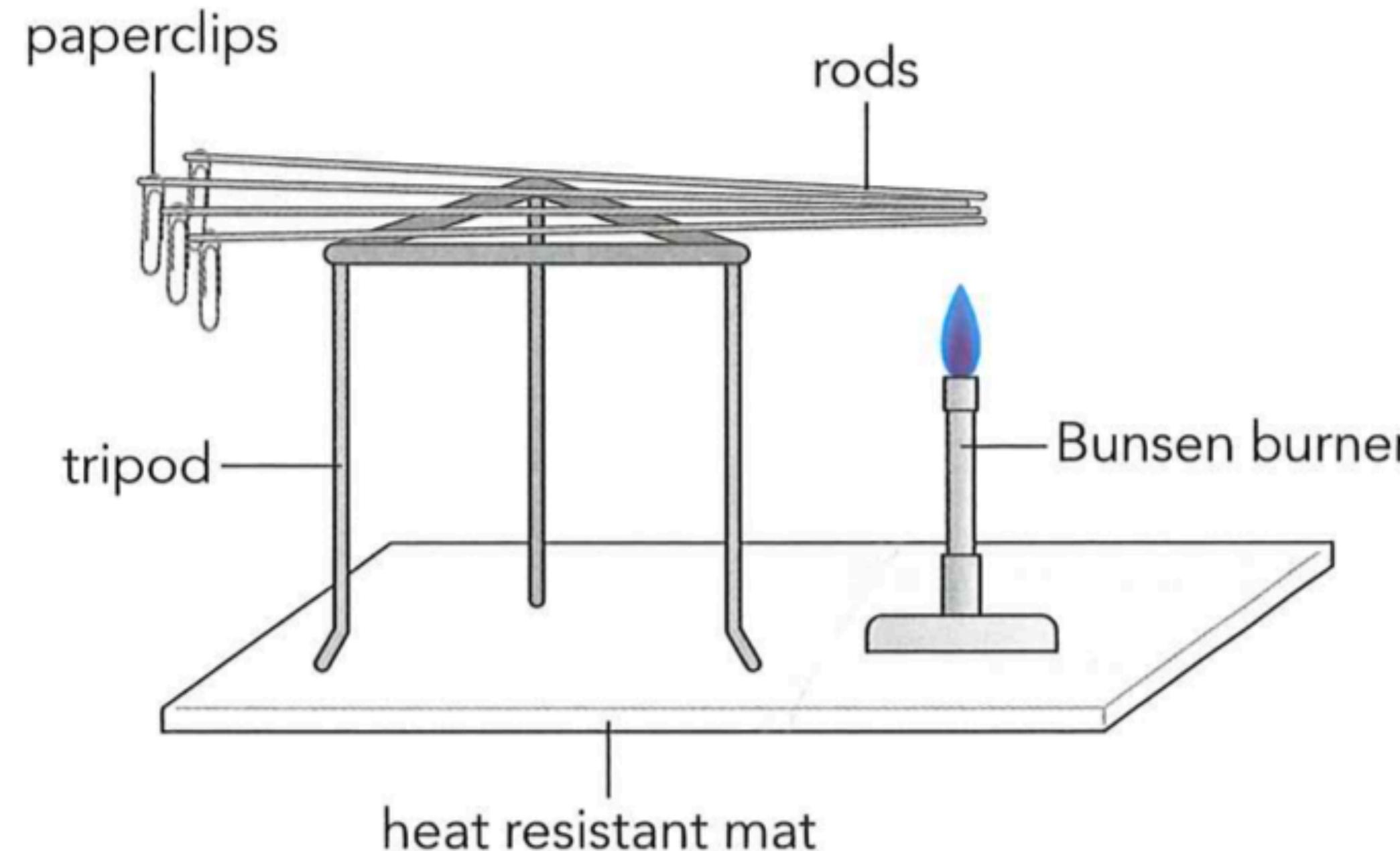
Part 1. How is thermal energy conducted along a metal bar



- What will happen to paperclips?
- What does this tell you about how thermal energy is conducted along the rod

Conductivity Experiments

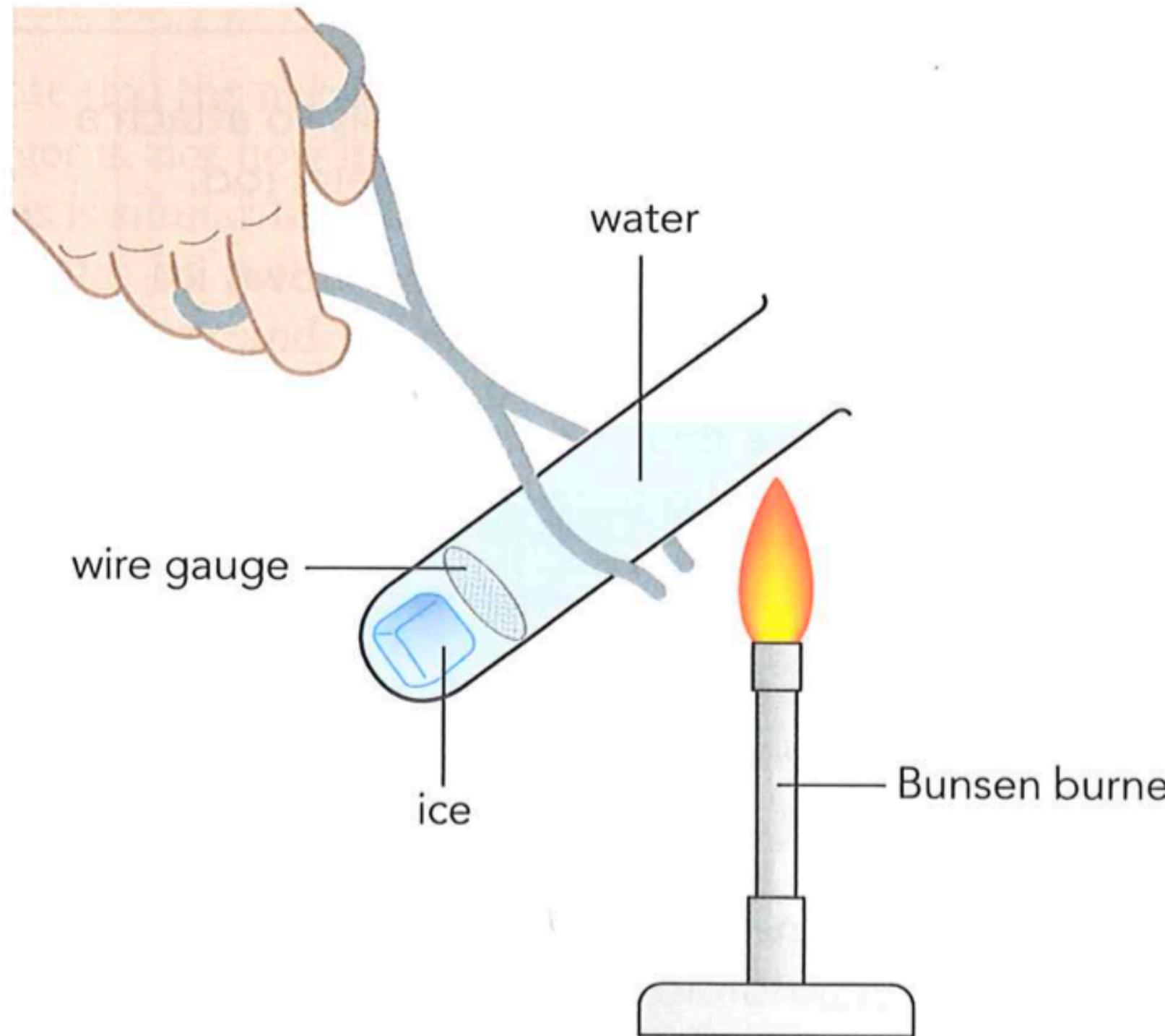
Part 2. Which metal is the best conductor?



- https://igexams.com/physics_exp_video/heat-conduction-in-metal-rods/
- What might be the source of experimental error?

Conductivity Experiments

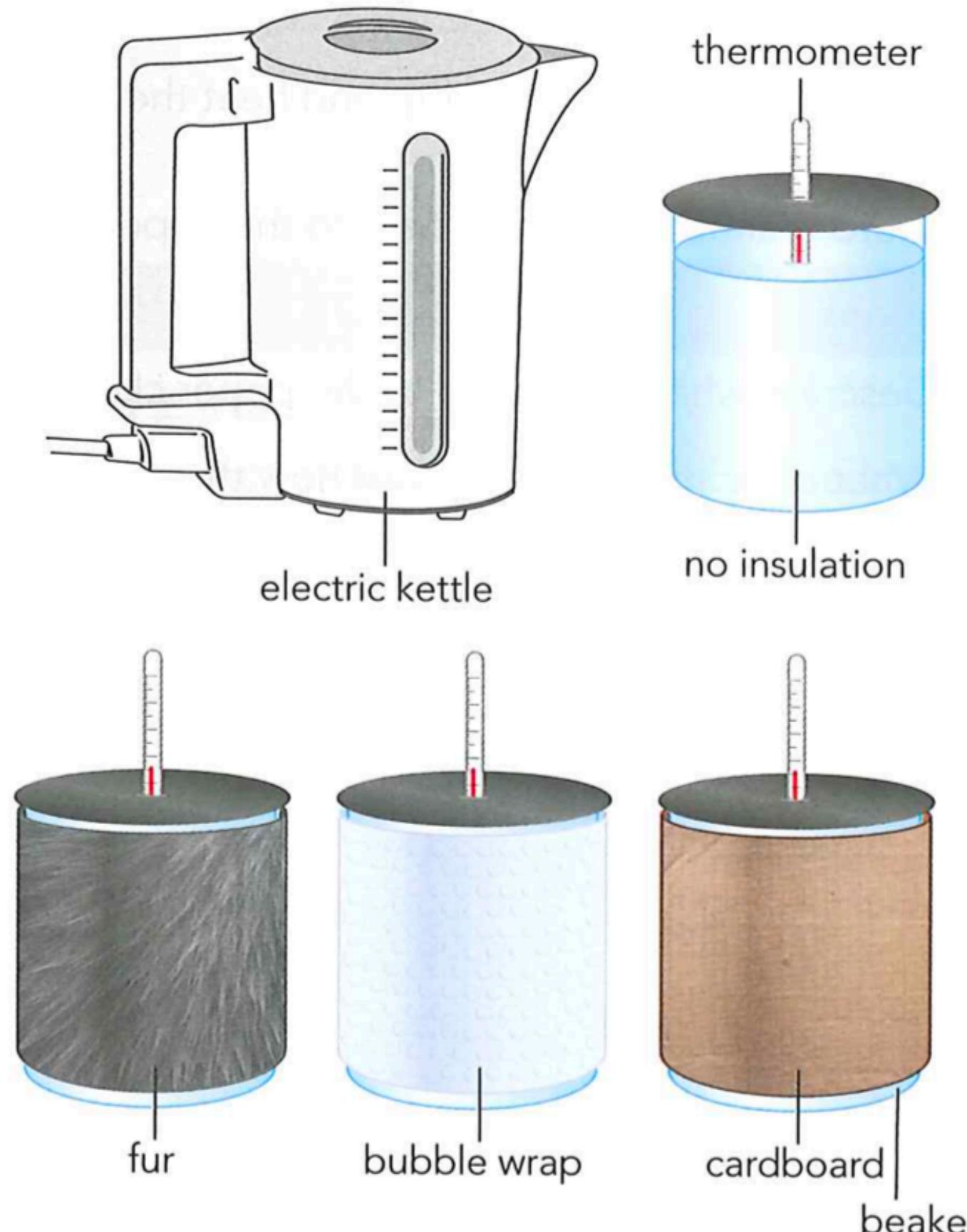
Part 3. Is water a good conductor of thermal energy?



- What might be your expected observations?
- Why do you expect that?

Conductivity Experiments

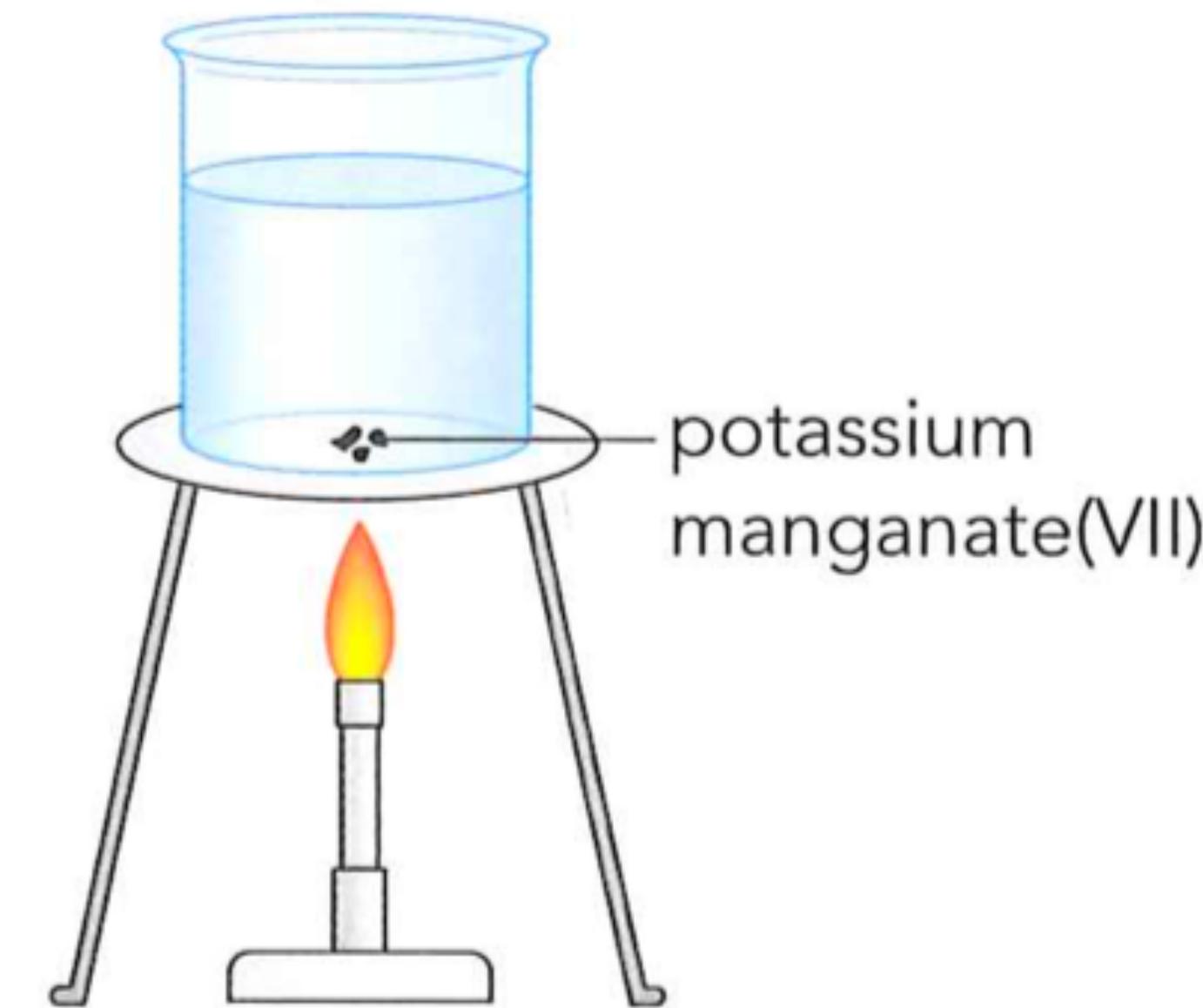
Part 4. Which materials make good insulators?



- Why was no-insulation beaker included?

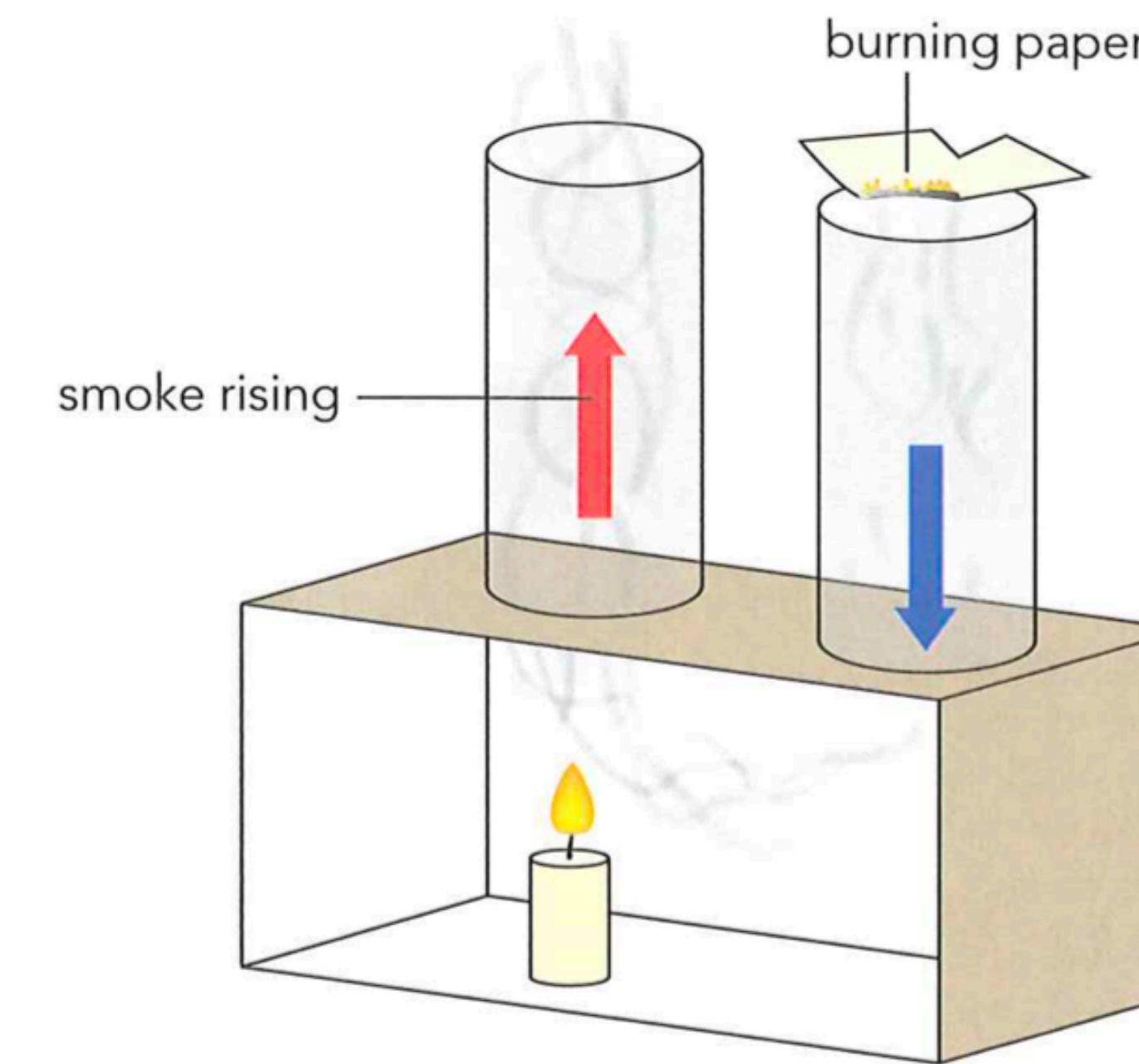
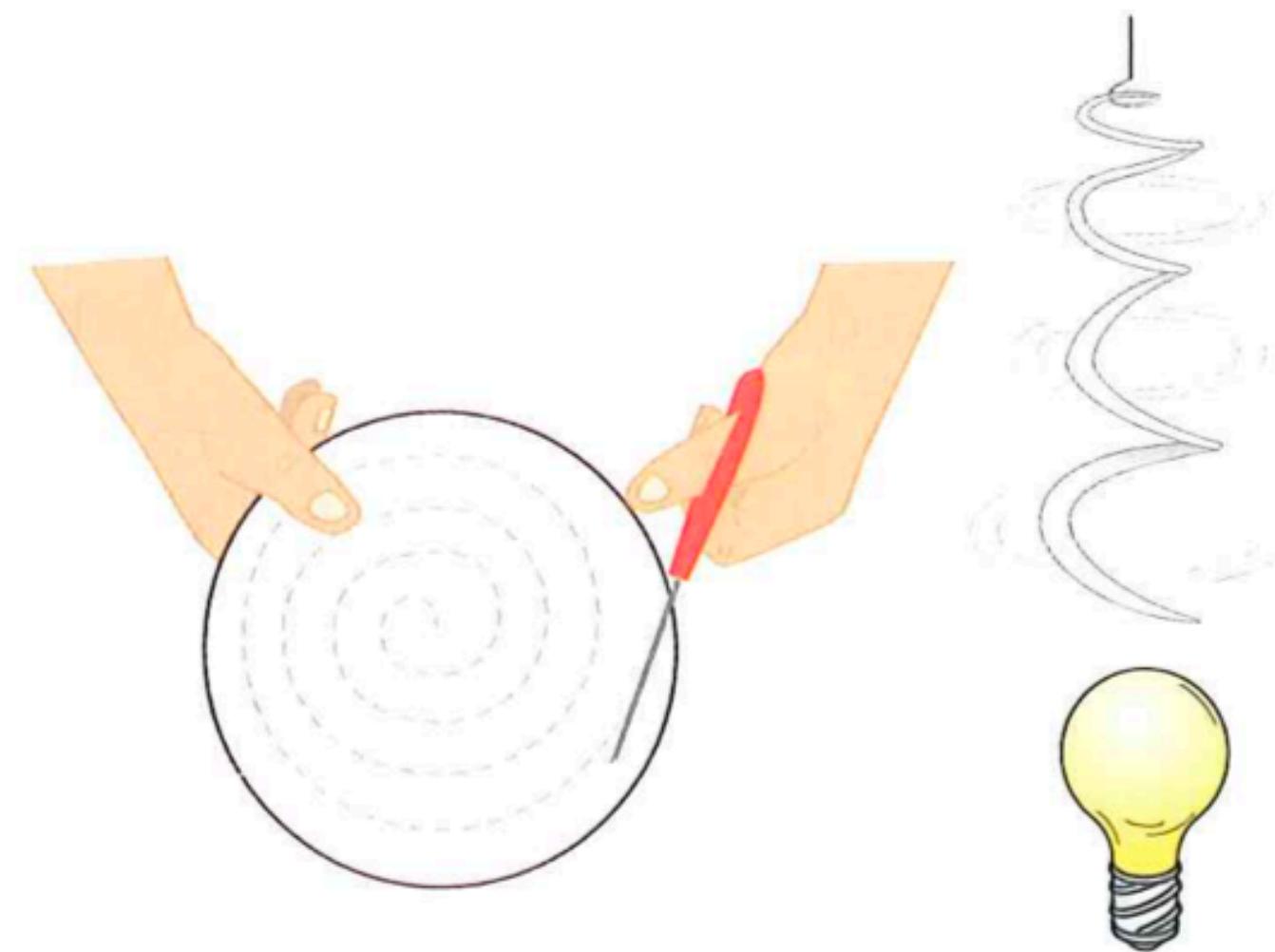
Convection experiment

Part 1. convection in a liquid?



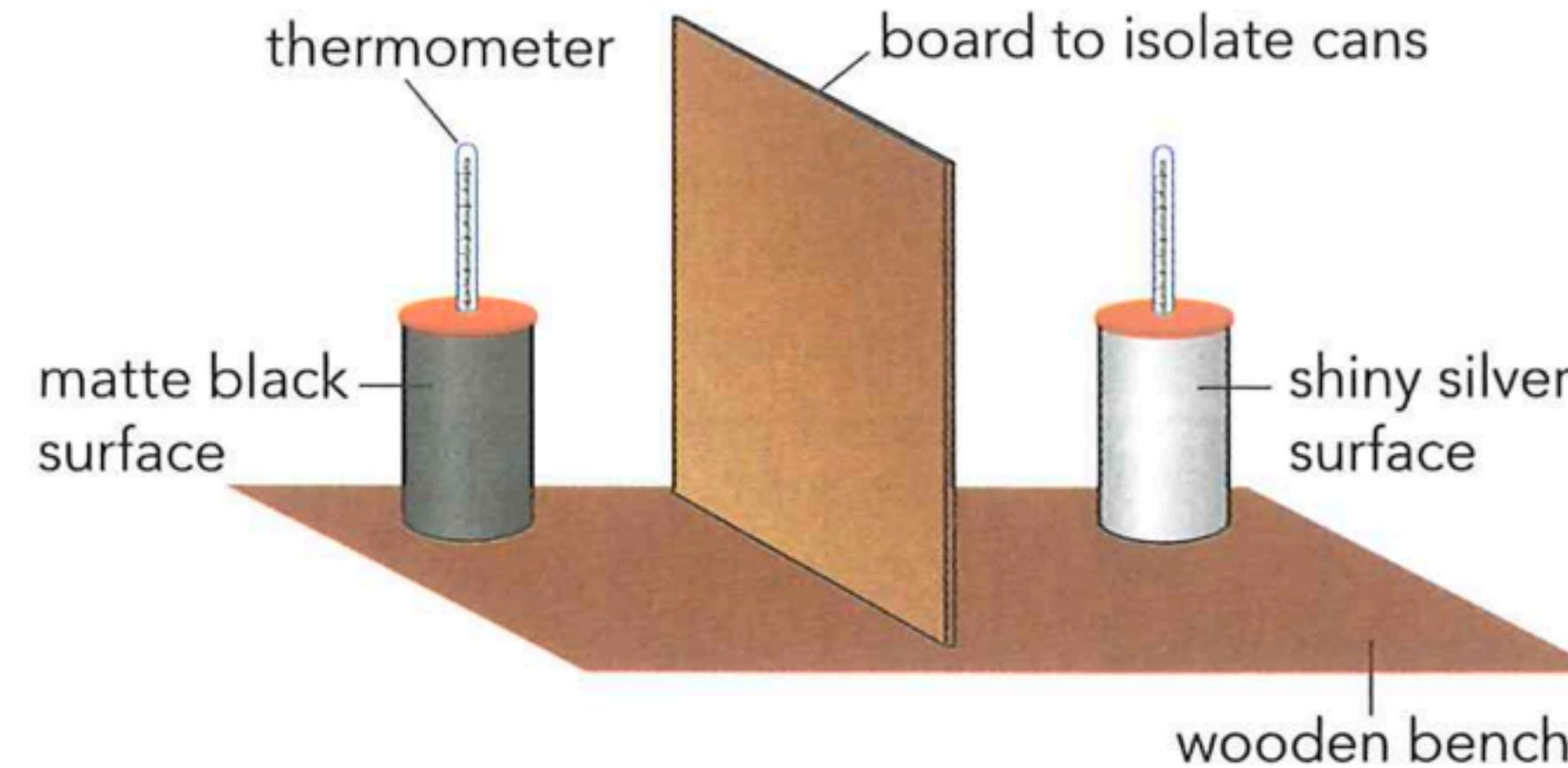
Convection experiment

Part 2. convection in air



Radiation experiment

Part 1. Which surface radiates better?



What determines how much energy is emitted?

Radiation experiment

Part 2. Which surface absorbs better?

