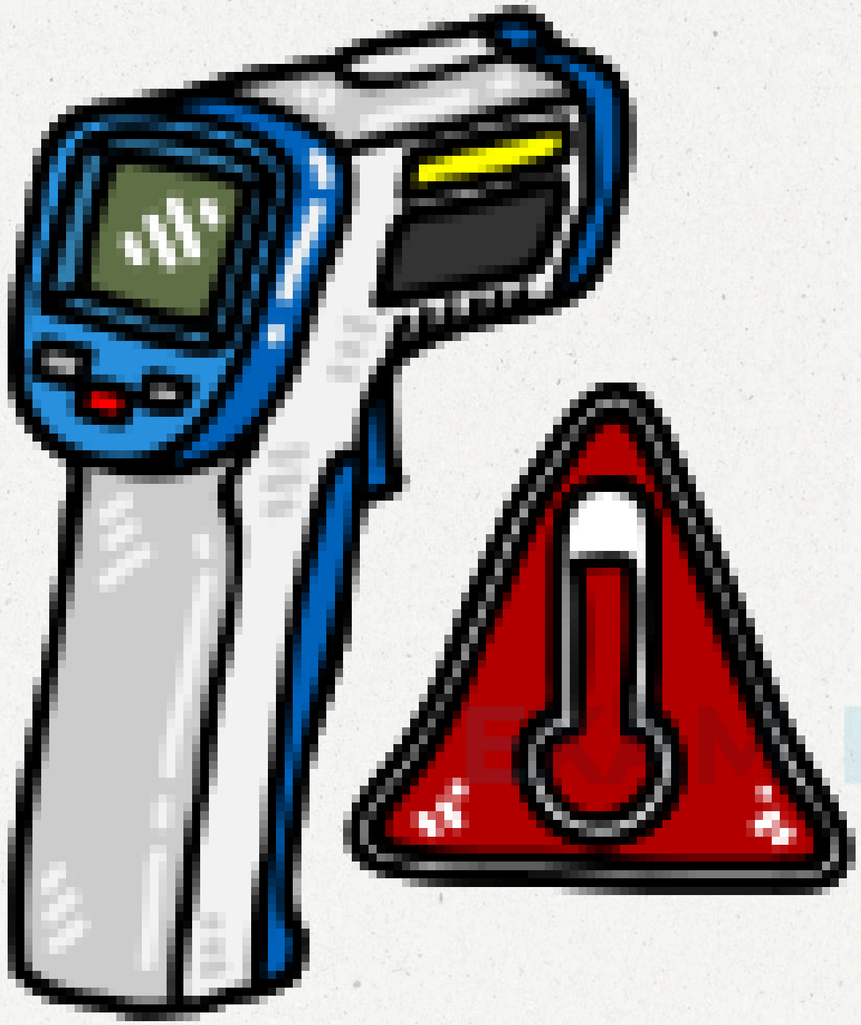


THERMAL ENERGY TRANSFER

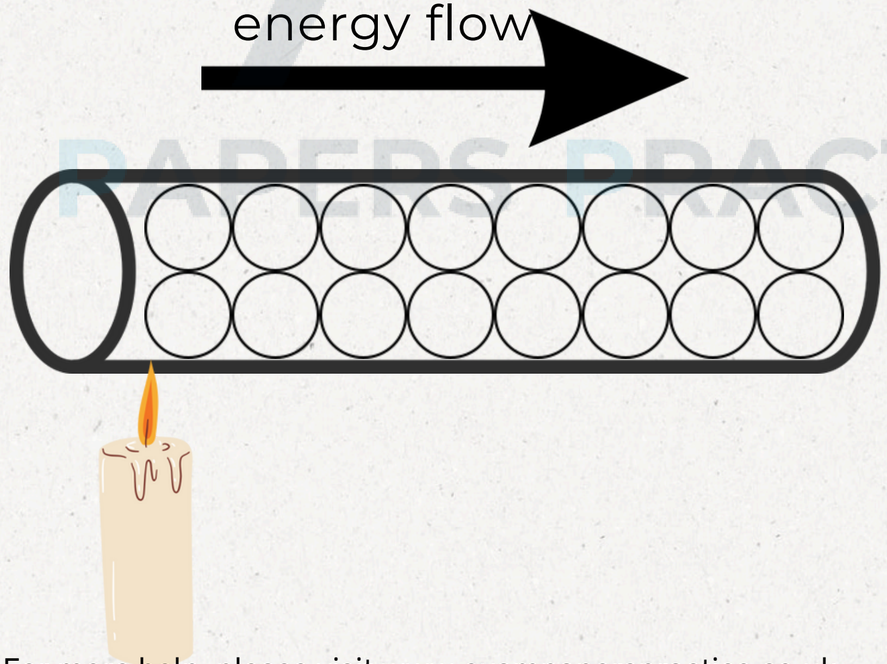
CIE IGCSE PHYSICS
FOR BOARD 0625 AND 0972
(FOR EXAMS 2025+)

11.1 CONDUCTION

1. TYPICALLY, METALS EXCEL IN TRANSFERRING THERMAL ENERGY, WHILE NONMETALS TEND TO BE LESS EFFECTIVE IN CONDUCTING HEAT.
2. BOTH AIR AND WATER EXHIBIT LOW EFFICIENCY IN TRANSFERRING THERMAL ENERGY. THE IMAGE BELOW COMPARES CONDUCTORS AND INSULATORS:

CONDUCTION OF NON-METALS

1. HEATING ONE END OF A GLASS ROD CAUSES INCREASED VIBRATION AMONG ITS ATOMS AT THAT END COMPARED TO THE COOLER END.
2. THESE VIBRATING ATOMS COLLIDE WITH ADJACENT ATOMS.
3. CONSEQUENTLY, EACH ATOM SHARES ITS ENERGY WITH NEIGHBOURING ATOMS.
4. OVER TIME, THESE COLLISIONS PROGRESSIVELY TRANSFER ENERGY FROM THE HEATED ATOMS TO THOSE AT THE COOLER END.
5. THIS GRADUAL PROCESS RESULTS IN THE STEADY TRANSFER OF ENERGY ALONG THE ROD, MOVING FROM THE HOT END TO THE COLD END.

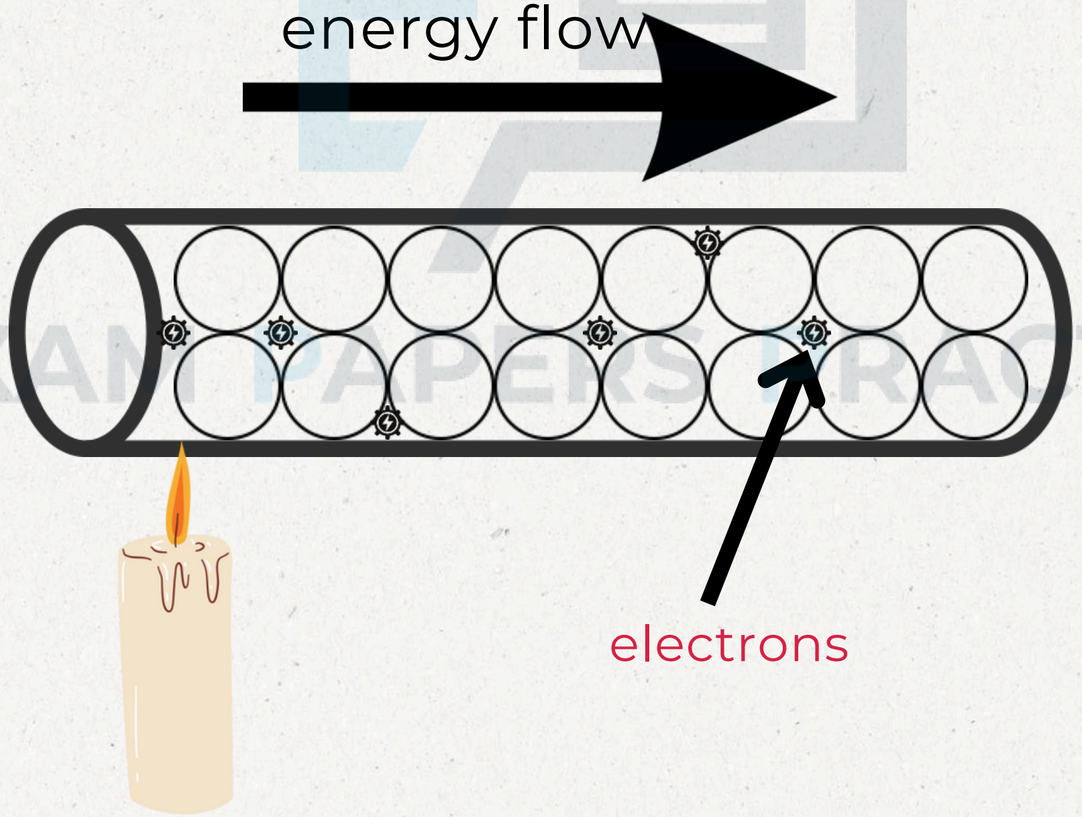


SSoollii

CONDUCTION OF METALS

EXAM PAPERS PRACTICE

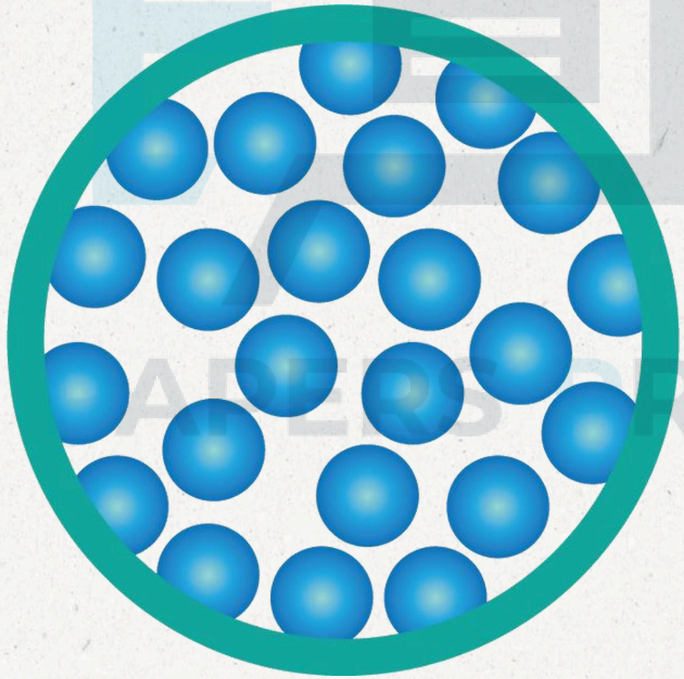
1. IN METALLIC CONDUCTORS, NUMEROUS ELECTRONS ARE UNBOUND AND CAPABLE OF FREE MOVEMENT.
2. THESE MOBILE ELECTRONS TRANSPORT THERMAL ENERGY AS THEY BECOME HEATED AND TRAVERSE THROUGH THE METAL.



Soli

CONDUCTION IN LIQUID

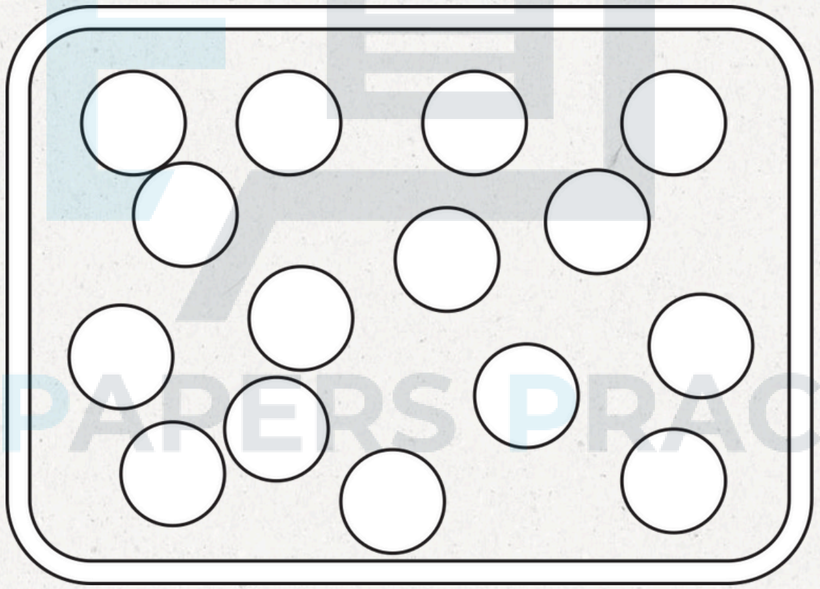
1. IN LIQUIDS, PARTICLES ARE CLOSELY PACKED TOGETHER.
2. BECAUSE THE PARTICLES CAN MOVE FREELY, VIBRATIONS ARE NOT TRANSMITTED AS EFFECTIVELY AS IN SOLIDS, RESULTING IN LIQUIDS BEING WEAKER CONDUCTORS COMPARED TO SOLIDS.



Liquid

CONDUCTION IN GAS

1. THE PARTICLES IN GASES ARE VERY SPREAD OUT, MAKING GASES VERY POOR CONDUCTORS OF THERMAL ENERGY.



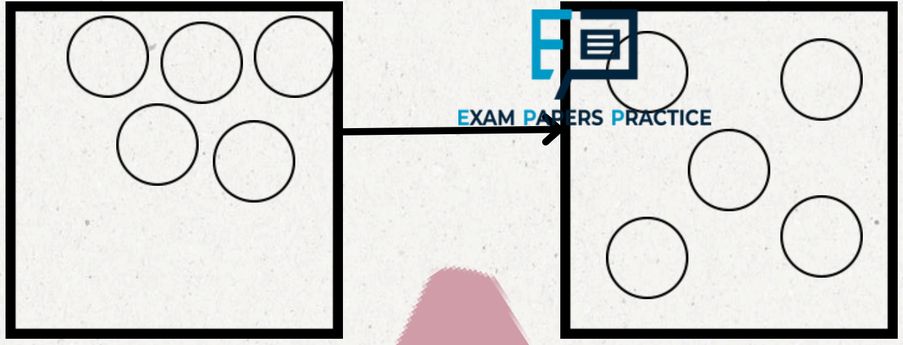
Gas

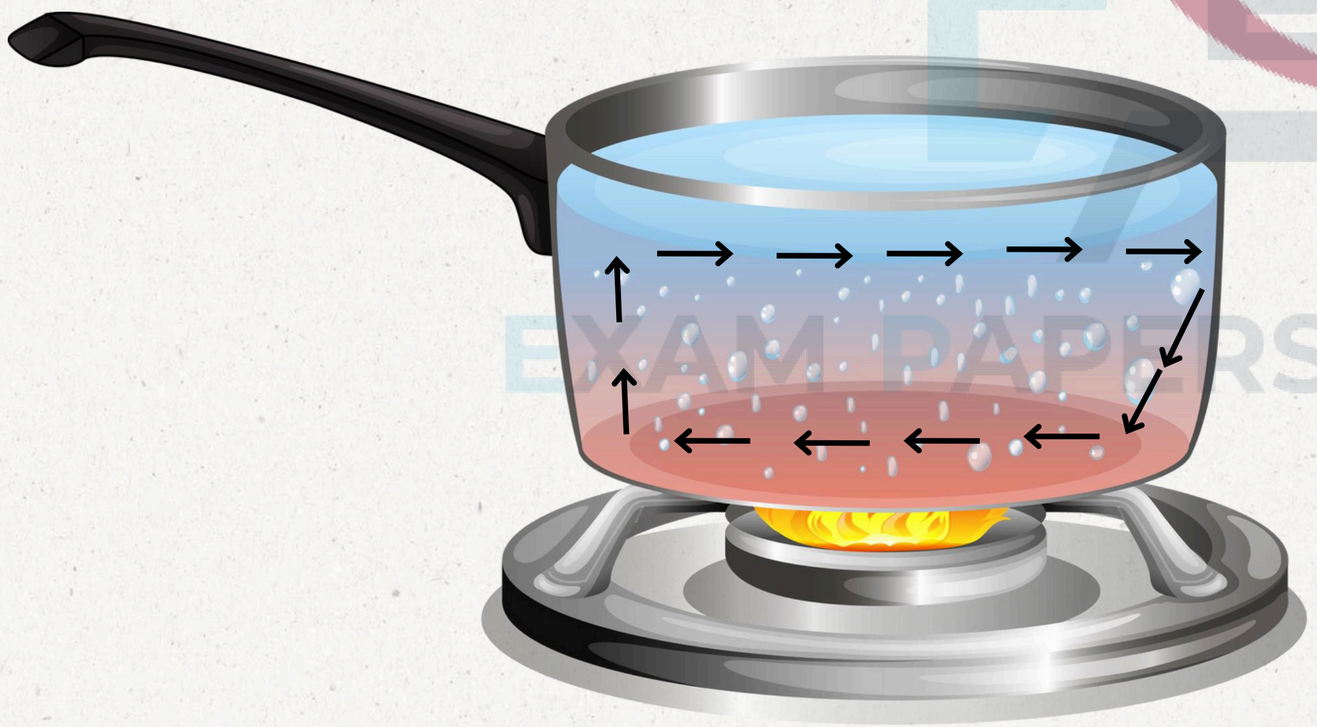
11.2 CONVECTION

EXAM PAPERS PRACTICE

"THERMAL ENERGY IN LIQUIDS AND GASES PRIMARILY TRANSFERS THROUGH A PROCESS CALLED CONVECTION."

11.2 CONVECTION

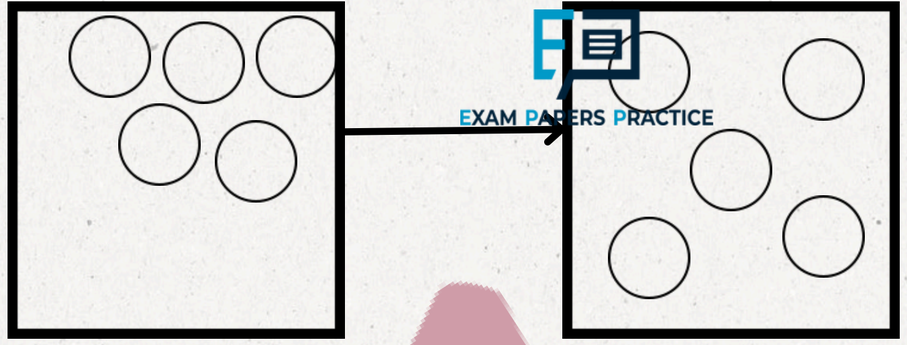




EXAMPLE 1: HOW CONVECTION WORKS?

1. THE WATER PARTICLES AT THE BOTTOM ARE HEATED, MAKING IT EXPAND.
2. AS THE WATER PARTICLES EXPAND (INCREASE IN VOLUME), ITS DENSITY DECREASES.
3. THIS RESULTS IN THE WATER PARTICLES AT THE BOTTOM RISE TO THE TOP. THE WATER PARTICLES AT THE TOP SINKS DUE TO BEING DENSER.
4. HEAT IS THEN TRANSFERRED THROUGHOUT THE LIQUID.

11.2 CONVECTION



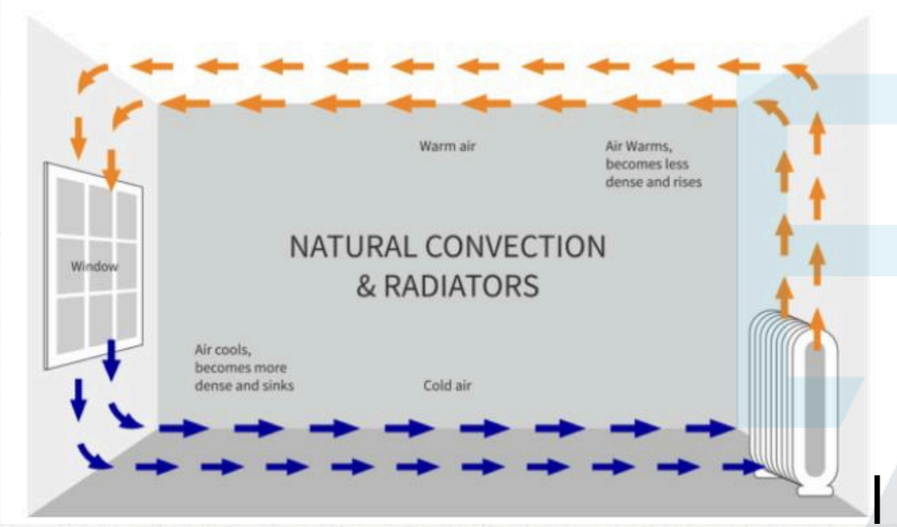
EXAMPLE 2: HOW CONVECTION WORKS FOR HOT AIR BALLOON?

1. WHEN AIR IS HEATED, IT EXPANDS, CAUSING ITS DENSITY TO DECREASE.
2. THE WARM AIR BECOMES LESS DENSE THAN THE SURROUNDING COOLER AIR, CAUSING IT TO RISE.
3. TO ACHIEVE FLIGHT, THE BALLOON, BASKET, AND PASSENGERS MUST COLLECTIVELY HAVE A LOWER DENSITY THAN THE COLD SURROUNDING AIR.

11.2 CONVECTION

Convection	Conduction
Transfer of heat through the movement of fluid (liquid or gas)	Transfer of heat through direct contact between materials

CONVECTION CURRENTS AT WORK



ELECTRIC HEATER

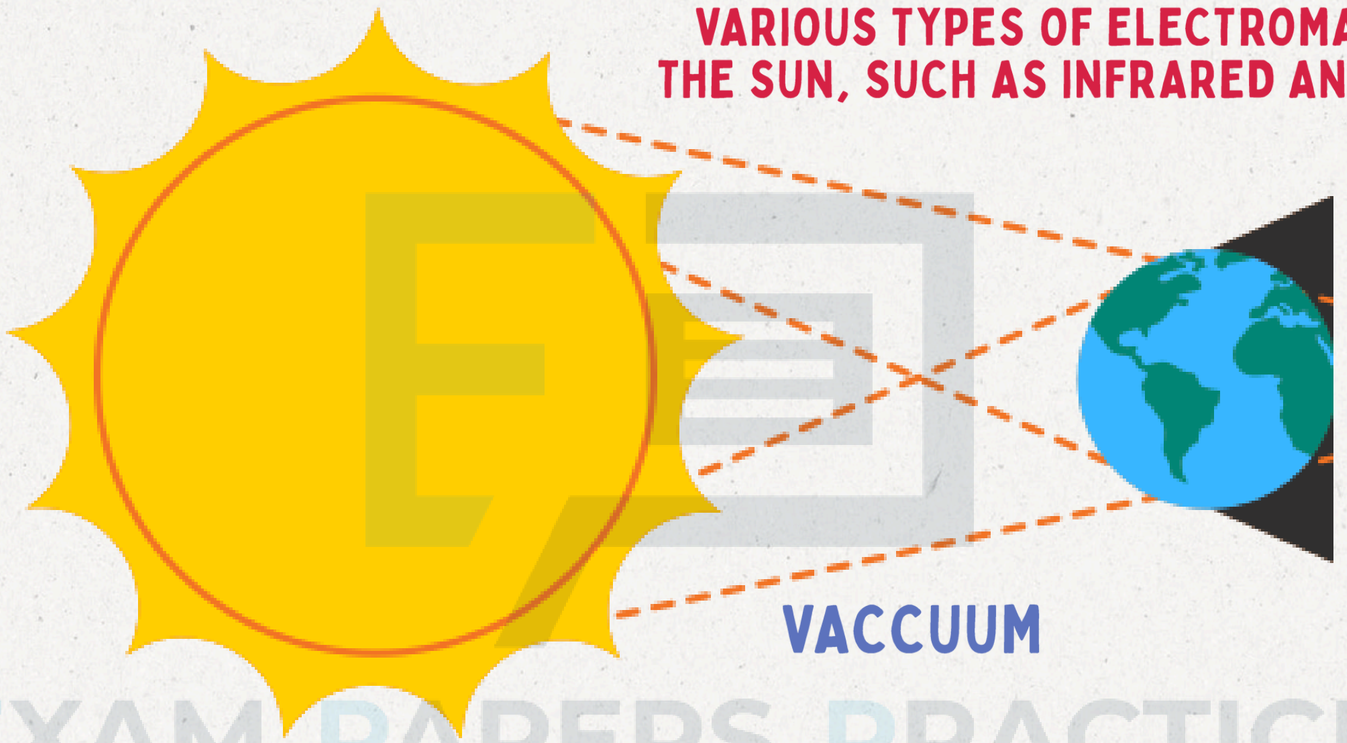
THERMAL ENERGY WILL BE MOVING AROUND THE ROOM FROM THE HEATER BECAUSE OF CONVECTION CURRENTS, WHICH RISE FROM THE HEATER.

REFRIGERATOR

IN A REFRIGERATOR, COLD AIR SINKS FROM THE FREEZING COMPARTMENT. IF THE FREEZER WAS AT THE BOTTOM, COLD AIR WOULD REMAIN THERE, AND THE FOOD AT THE TOP WOULD NOT BE COLD.

11.3 RADIATION

IN ADDITION TO VISIBLE LIGHT, THE EARTH RECEIVES VARIOUS TYPES OF ELECTROMAGNETIC RADIATION FROM THE SUN, SUCH AS INFRARED AND ULTRAVIOLET RADIATION.



PROPAGATE WITHOUT REQUIRING A MEDIUM.

11.3 RADIATION

1. ALL OBJECTS EMIT INFRARED RADIATION.
2. [redacted]
   INCREASES WITH ITS TEMPERATURE.

11.3
RADIATION

CHARACTERISTIC OF INFRARED RADIATION

- PRODUCED BY WARM OR HOT OBJECTS
- FORM OF ELECTROMAGNETIC RADIATION
- PROPAGATES THROUGH EMPTY SPACE IN WAVE FORM.
- TRAVELS IN STRAIGHT LINES
- WARMS OBJECTS UPON ABSORPTION
- INVISIBLE TO THE NAKED EYE
- DETECTABLE BY NERVE CELLS IN THE SKIN

GOOD ABSORBERS, GOOD EMITTERS

SURFACES THAT REFLECT WELL, SUCH AS SHINY OR WHITE SURFACES, TEND TO BE **POOR ABSORBERS** OF INFRARED RADIATION.

SURFACES THAT ABSORB WELL, LIKE MATTE BLACK SURFACES, ARE TYPICALLY **GOOD EMITTERS** OF INFRARED RADIATION.

SUNSHIELD

RADIATION FROM THE SUN.

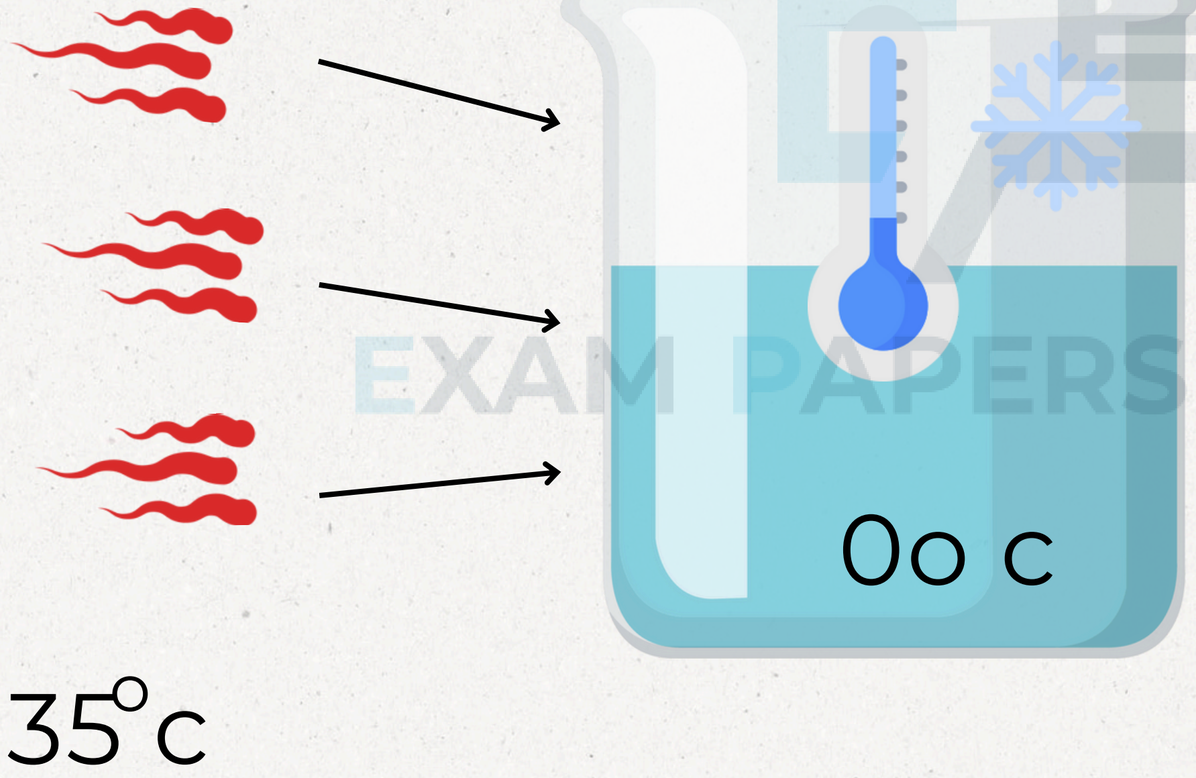
EXAM PAPERS PRACTICE

SCENARIO 1: AN OBJECT THAT IS HOTTER THAN ITS SURROUNDING.

RADIATE MORE ENERGY PER SECOND THAN IT ABSORBS AND SO WILL COOL DOWN.

EXAM PAPERS PRACTICE

SCENARIO 2: AN OBJECT THAT IS COOLER THAN ITS SURROUNDING.

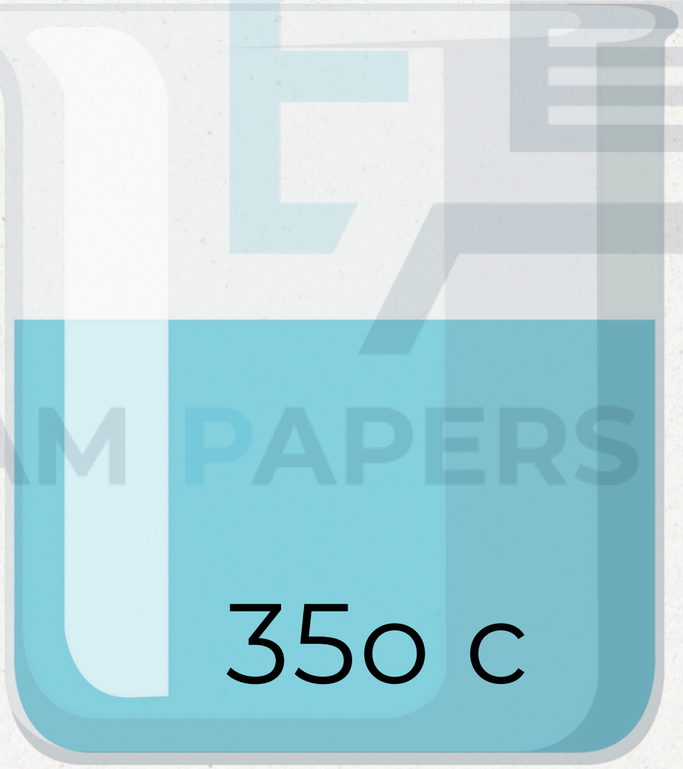


ABSORBS MORE ENERGY PER SECOND THAN IT RADIATES UNTIL IT REACHES THE TEMPERATURE OF ITS SURROUNDINGS.

EXAM PAPERS PRACTICE

SCENARIO 3: AN OBJECT WITH A TEMPERATURE SIMILAR TO SURROUNDING.

35o c

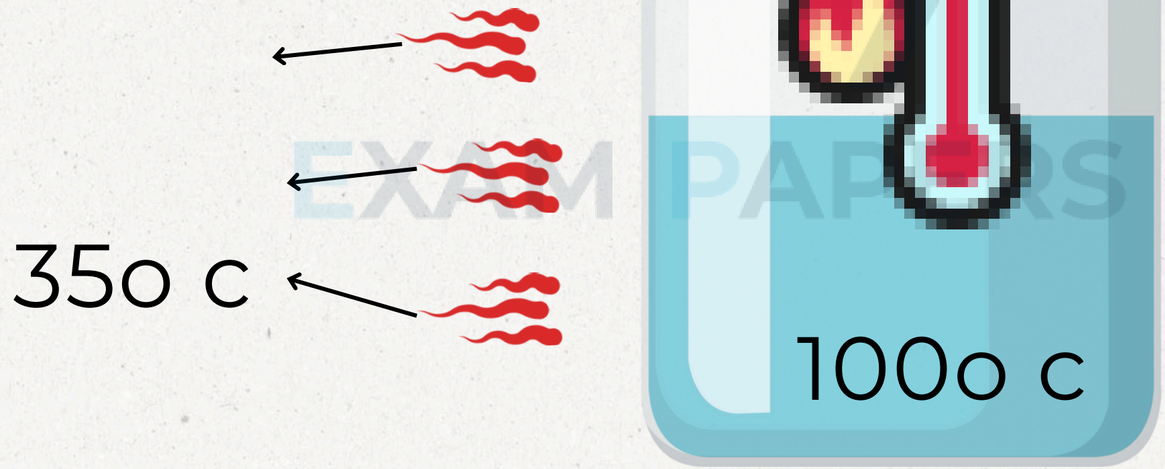


ABSORBS THERMAL ENERGY AT THE SAME RATE AS IT EMITS THERMAL ENERGY.

11.4
CONSEQUENCES OF THERMAL ENERGY TRANSFER

EXAM PAPERS PRACTICE

THERMAL ENERGY TRANSFER



THERMAL ENERGY TRAVELS FROM A HOTTER PLACE TO A COLDER PLACE.
IT IS THE TEMPERATURE DIFFERENCE THAT MAKES IT FLOW.

11.4 CONSEQUENCES OF THERMAL ENERGY TRANSFER

EXAM PAPERS PRACTICE

INSULATION

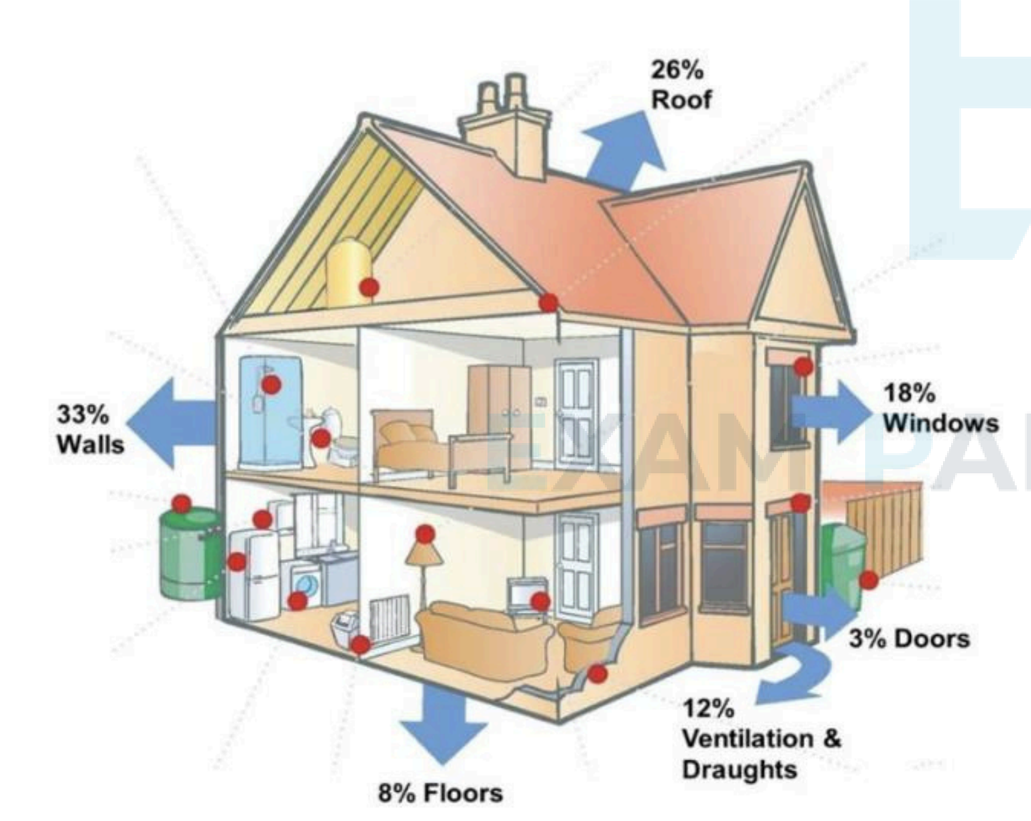
35o c

TO RETAIN THERMAL ENERGY IN AN OBJECT HOTTER THAN ITS SURROUNDINGS, INSULATION IS NECESSARY.

11.4.1 HOME INSULATION

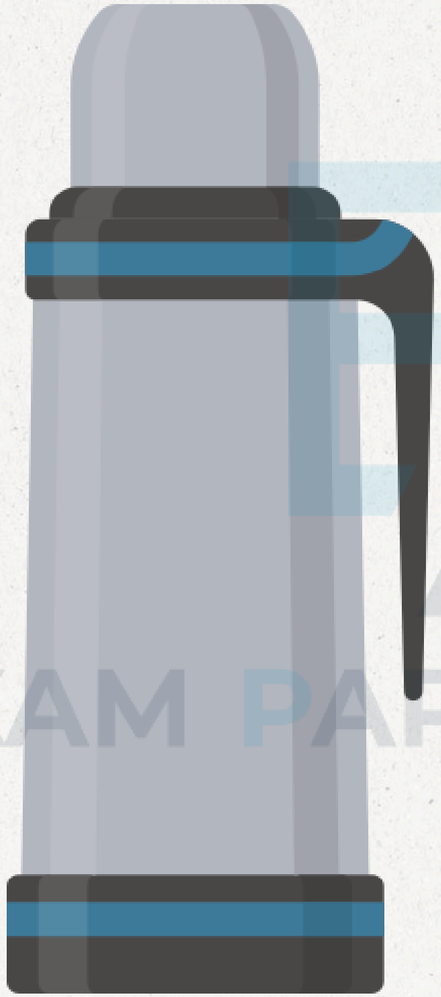
A WELL-INSULATED HOUSE CAN AVOID A LOT OF ENERGY WASTAGE DURING COLD WEATHER. INSULATION CAN HELP THE HOUSE FROM BECOMING UNCOMFORTABLY HOT DURING WARM WEATHER.

11.4.1 HOME INSULATION METHODS



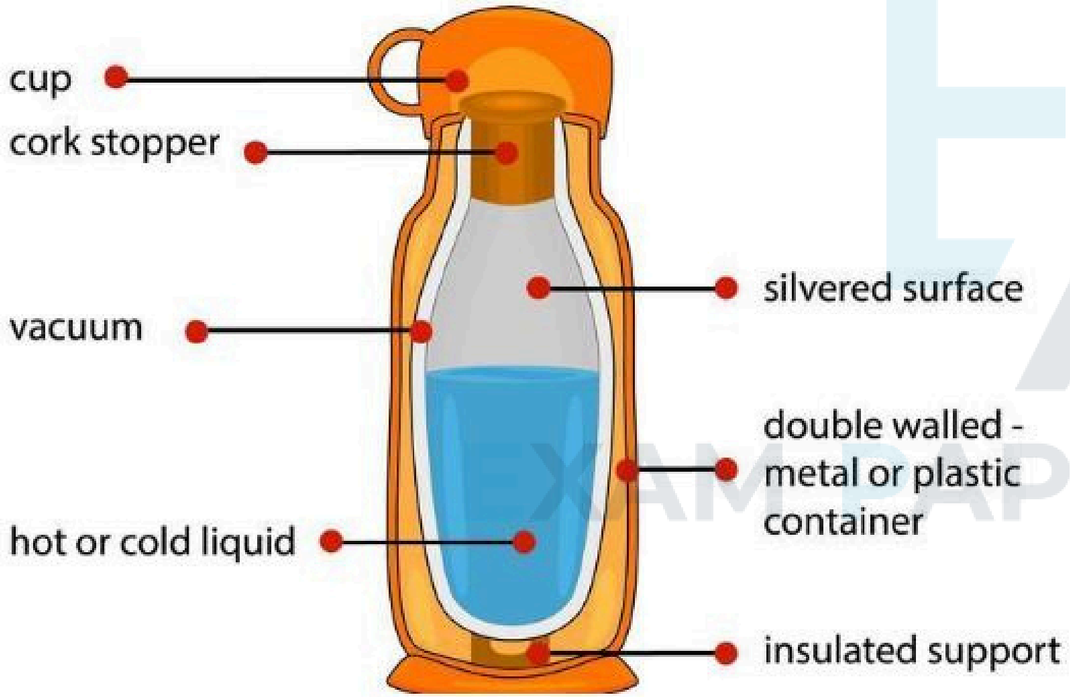
METHOD	WHY DOES IT WORK?
DRAUGHT PROOFING	SEALING GAPS AROUND DOORS, WINDOWS, AND FLOORS REDUCES HEAT LOSS THROUGH CONVECTION BY BLOCKING AIR MOVEMENT.
LOFT INSULATION	INSTALLING INSULATING MATERIALS (E.G., FIBERGLASS, CELLULOSE) IN THE ATTIC FLOOR REDUCES HEAT LOSS BY CONDUCTION AND CONVECTION THROUGH THE ROOF.
DOUBLE AND TRIPLE GLAZING OF WINDOWS	USING TWO PANES OF GLASS WITH A LAYER OF INSULATING GAS (E.G., ARGON) IN BETWEEN REDUCES HEAT LOSS THROUGH CONDUCTION AND CONVECTION IN WINDOWS.
CAVITY WALLS	INJECTING INSULATING MATERIAL (E.G., FOAM, MINERAL WOOL) INTO THE GAP BETWEEN OUTER AND INNER WALLS REDUCES HEAT LOSS THROUGH CONDUCTION.
REFLECTIVE INSULATION	INSTALLING REFLECTIVE BARRIERS (E.G., FOIL-BACKED INSULATION) REFLECTS RADIANT HEAT, REDUCING HEAT TRANSFER BY RADIATION.

11.4.2 VACUUM FLASK



A VACUUM FLASK IS EFFECTIVE FOR MAINTAINING THE TEMPERATURE OF BOTH HOT AND COLD DRINKS.

11.4.2 VACUUM FLASK



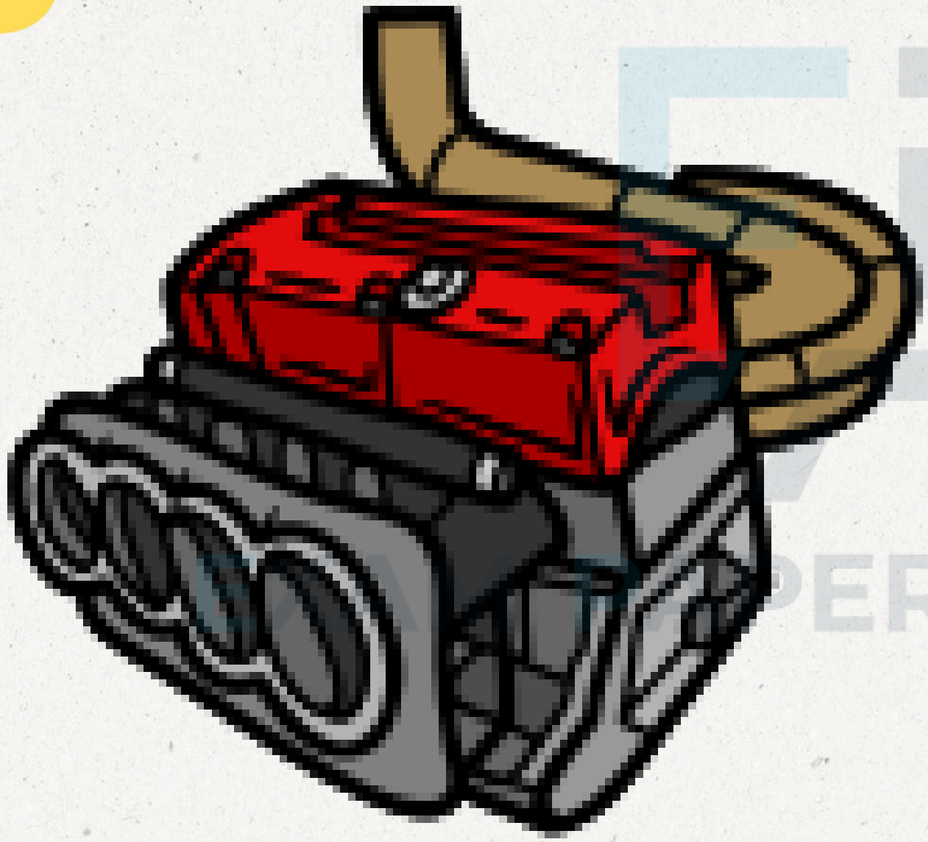
GLASS IS CHOSEN FOR ITS EXCELLENT INSULATION PROPERTIES.

AIR IS REMOVED FROM BETWEEN THE DOUBLE WALLS TO CREATE A VACUUM, MINIMIZING HEAT LOSS THROUGH CONDUCTION AND CONVECTION, AS BOTH REQUIRE A MEDIUM FOR HEAT TRANSFER.

SILVER COATING ON THE GLASS REDUCES HEAT LOSS BY REFLECTING INFRARED RADIATION.

THE PLASTIC STOPPER PREVENTS HEAT LOSS THROUGH CONVECTION AND REDUCES EVAPORATION.

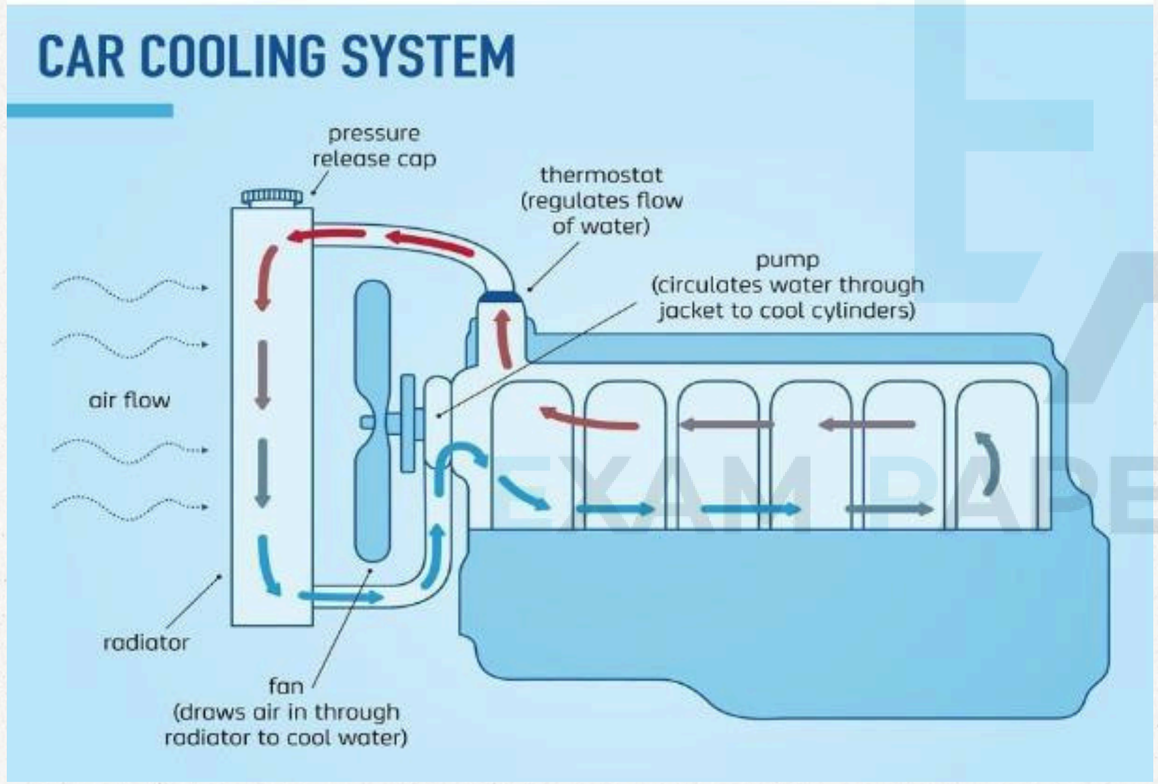
11.4.3
CAR ENGINE



A CAR ENGINE GENERATES INTENSE HEAT THROUGH BURNING FUEL, WHICH MUST BE MANAGED BY THE COOLING SYSTEM TO PREVENT OVERHEATING.

11.4.3 CAR ENGINE

HOW CAR COOLING SYSTEM RELEASES HEAT



SPECIFIC HEAT CAPACITY: A.WATER CIRCULATES AROUND THE ENGINE BLOCK TO ABSORB THERMAL ENERGY EFFICIENTLY, CHOSEN FOR ITS HIGH SPECIFIC HEAT CAPACITY.

CONVECTION: A.HEATED WATER CREATES A CONVECTION CURRENT, FLOWING AS INDICATED BY ARROWS, WITH A PUMP ACCELERATING THIS CIRCULATION.

CONDUCTION: A.METAL FINS ON THE RADIATOR FACILITATE THE CONDUCTION OF THERMAL ENERGY THROUGHOUT THE RADIATOR.

RADIATION: A.FINS ARE DESIGNED WITH A LARGE SURFACE AREA AND PAINTED BLACK TO ENHANCE THE EMISSION OF THERMAL ENERGY THROUGH RADIATION.

11.4.4 THERMAL ENERGY TRANSFER, CLIMATE, AND WEATHER

EXAM PAPERS PRACTICE

GLOBAL WARMING

1. GASES LIKE CARBON DIOXIDE IN THE EARTH'S ATMOSPHERE ABSORB THERMAL ENERGY, CONTRIBUTING TO THE WARMING OF OUR ATMOSPHERE.
2. THE CONCENTRATION OF GREENHOUSE GASES IN THE ATMOSPHERE IS RISING, LEADING TO INCREASED TRAPPING OF THERMAL ENERGY.
3. EARTH IS NOW ABSORBING MORE INFRARED RADIATION THAN IT EMITS, WHICH IS THE PRIMARY CAUSE OF GLOBAL WARMING.

11.4.4 THERMAL ENERGY TRANSFER, CLIMATE, AND WEATHER

EXAM PAPERS PRACTICE

OCEAN CURRENT

1. OCEAN CURRENTS FACILITATE THE DISTRIBUTION OF THERMAL ENERGY FROM EQUATORIAL REGIONS TO COOLER PARTS OF THE EARTH`S SURFACE.
2. SURFACE WARM WATER MOVES TOWARDS THE POLES, WHILE IN POLAR REGIONS, COLDER WATER SINKS AND RETURNS TOWARDS THE EQUATOR IN A CONTINUOUS CIRCULATION PATTERN.

WORKED EXAMPLE

THE COAT BELOW IS DESIGNED FOR A COLD CLIMATE.

DESCRIBE THE FEATURES OF THE COAT WHICH PREVENT THERMAL ENERGY LOSS BY

A. CONDUCTION
B. CONVECTION
C. RADIATION

WORKED EXAMPLE

EXAM PAPERS PRACTICE

SOLUTION

THE PADDED COAT TRAPS AIR, WHICH ACTS AS AN EFFECTIVE INSULATOR BECAUSE THE AIR CANNOT MOVE, THEREBY PREVENTING HEAT LOSS THROUGH CONVECTION. ADDITIONALLY, THE SILVER LINING REFLECTS HEAT RADIATION BACK TOWARDS THE PERSON`S BODY.