t 21 Heat Transfer: (3) Convection

Vocabulary

crystal	mainly	permanganate	vessel
current	movement	of potash	

A

If you fill a glass vessel with water and drop into it a few crystals of *permanganate of potash – written like this in chemistry*: $KMnO_4$ – you see that the water near the crystals turns pink. If you heat the water, you can see the way in which the pink water moves. First it rises, then it moves across the surface, and then it sinks down the side of the vessel.

Movement of water is known as current. As the water moves, it carries the heat with it, and we say that the heat travels by convection. *The name we give to these movements is* convection currents. Heat does not travel by convection in a solid, because the solid does not move, *like a liquid does*. We find convection currents only in *liquids and gases*.

To put the main ideas into a few words: The three methods of heat transfer are (i) radiation, (ii) conduction, and (iii) convection. Heat travels by radiation in space or in gases, by conduction in solids, and mainly by convection in liquids and gases.

The sun radiates heat, and this is known as *the passing on of heat* by radiation. Solids conduct heat, and this is known as heat passed on by conduction. Liquids and gases convect heat, and this is known as heat passed on by convection.

B

If a glass vessel is filled with water and a few crystals of (1)potassium permanganate – (2)chemical formula: $KMnO_4$ – are dropped into it, the water near the crystals is seen to turn pink. If the water is heated, the way in which the pink water moves can be seen. First it rises, then it moves across the surface, and then it sinks down the side of the vessel.

Movement of water is known as current. As the water moves, the heat is carried with it, and the heat is said to travel by convection. (3)These movements are known as convection currents. Heat does not travel by convection in a solid, because the solid does not move (4)as does a liquid. Convection currents are found only in (5)fluids.

(6)To summarize: The three methods of heat transfer are (i) radiation, by which heat travels in space or in gases, (ii) conduction, by which heat travels in solids, and (iii) convection, by which heat travels mainly in (5)fluids.

Heat is radiated by the sun, and this is known as (7)heat transfer by radiation. Heat is conducted in solids, and this is known as (7)heat transfer by conduction. Heat is convected in (5)fluids, and this is known as (7)heat transfer by convection.

Exercise 1 Find the way in which the words and phrases italicised in Text A are expressed in Text B:

1 permanganate of potash
2 written like this in chemistry
3 The name we give to these movements is
4 like a liquid does
5 liquids and gases
6 To put the main ideas into a few words
7 the passing on of heat

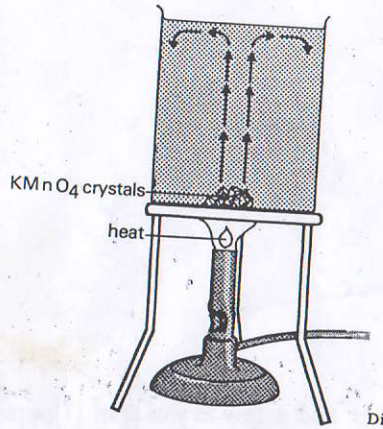

Diagram of convection currents

Exercise 2 DO/DOES/DID are used to avoid repeating a verb or verb phrase in a sentence. (Notice the change in word order):

(a) The solid does not move as *the liquid moves*.
(b) The solid does not move as *does the liquid*.

Rewrite these sentences, avoiding the repetition, as in example (b):

1 The handle of a wooden spoon does not become hot as that of a silver spoon *becomes hot*.
2 Poor insulators do not prevent heat from escaping as good insulators *prevent it from escaping*.
3 Poor conductors do not conduct heat readily as good conductors *conduct heat readily*.
4 Currents of air rise when heated just as currents of water *rise when heated*.
5 Heat travels by convection in a gas just as heat *travels by convection* in a liquid.
6 Conducted or convected heat does not travel through a vacuum as radiated heat *travels through a vacuum*.
7 Radiated heat does not pass from one molecule to the next as conducted heat *passes from one molecule to the next*.
8 The molecules in a fluid do not transfer heat to one another as those of a solid *transfer it to one another*.
9 Nitrogen does not support combustion as oxygen *supports it*.
10 The candle did not burn in nitrogen as the candle *burned* in oxygen.

Exercise 3 Rewrite this passage, using passive forms. You will then have summarised the passage. (The subjects of the passive sentences are italicised):

If we fill *a glass vessel* with water and drop *a few crystals of $KMnO_4$* into it, we can see *the water near the crystals* turn pink. If we heat *the water*, we can see *the way in which the pink water moves*. We call *the movements of water* currents. As the water moves, it carries *the heat* with it. We say that *this* is heat transfer by convection, and we call *these movements* convection currents. We find *convection currents* only in fluids. Solids conduct *heat*; the sun radiates *heat*; and fluids convect *heat*.

Exercise 4 Answer these questions without referring to the Texts:

1 Why are crystals of $KMnO_4$ dropped into the water before heating it? In other words, why should we want to colour the water for this experiment?
2 In which directions does the water move when heated?
3 What is convection and what are convection currents?
4 Where are convection currents found?
5 Where does heat travel (a) by radiation? (b) by conduction? and (c) by convection?

Exercise 5 Questions for further discussion:

1 Give examples of the way in which heat transfer by radiation and convection is used. (How is your classroom heated? How does heat travel through the room?)
2 How is the hot water supplied to a house or other building?
3 Make a list of good conductors and good insulators.
4 Explain why our bare feet feel cold on a stone floor but not on a carpet.
5 Why does a piece of iron feel cold but a piece of wood doesn't?

Vocabulary
bare

t 22 A Vacuum Flask

Vocabulary
flask

A

A vacuum flask *is made out of* two very thin walls of glass, *and* a vacuum *is* between the two walls. *When we say that we mean* that we have *taken out* the air and everything else.

We have seen that radiation, conduction and convection can *pass heat along*. If the space between the walls is a vacuum however, heat cannot be passed along by either conduction or convection. It could be passed along by radiation, but in order to *stop this from happening, the inside* of the glass walls is *covered with a very thin layer of shiny metal*. This is done in order to *throw back* the heat into the flask, *instead of letting* it *get away*.

In this way, very little heat is lost by radiation, so we *can keep hot things hot* in the flask for *a long time*. We can also use a vacuum flask to keep cold things cold for a long time. *Because* heat cannot get away from the inside, *in the same way*, heat from *the outside* cannot *get through*.

B

A vacuum flask (1)consists of two very thin walls of glass, a vacuum (2)being between the two walls. (3)By this is meant that the air and everything else has been (4)extracted.

It has been seen that heat can be (5)transferred by radiation, conduction and convection. If the space between the walls is a vacuum however, heat cannot be (5)transferred by either conduction or convection. It could be (5)transferred by radiation, but in order to (6)prevent this, (7)the interior of the glass walls is (8)silvered. This is done in order to (9)reflect the heat back into the flask, (10)rather than allowing it (11)to escape.

(12)Thus, very little heat is lost by radiation, so that heat (13)can be preserved in the flask for (14)long periods. A vacuum flask can also be used to (12)preserve the cold for (14)long periods. (15)Since heat cannot (11)escape from (7)the interior, (16)similarly heat from (17)the exterior cannot (18)penetrate.

Exercise 1 Find the way in which the words and phrases italicised in Text A are expressed in Text B:

1 is made out of
2 and . . . is
3 When we say that we mean
4 taken out
5 pass (heat) along
6 stop this from happening
7 the inside
8 covered with a very thin layer of shiny metal
9 throw back
10 instead of letting
11 get away
12 In this way
13 can keep (hot things hot)
14 a long time
15 Because
16 in the same way
17 the outside
18 get through

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Exercise 2 BEING is sometimes used instead of *and . . .is* to show that the second idea is the result of, or the reason for, the first:

(a) The flask has two walls *and* a vacuum *is* between them.
(b) The flask has two walls, a vacuum *being* between them.

Rewrite these sentences, combining where necessary, as in example (b):

1 The air and everything else has been extracted, and the result is a vacuum.
2 Very little heat is lost through the walls, and the heat is kept in by the vacuum.
3 In a vacuum, heat cannot be transferred by conduction or convection, and the only method left is by radiation.
4 Heat is reflected back into the flask. The interior of the walls is silvered.
5 Heat cannot penetrate from the exterior. The outside of the walls is silvered.
6 Neither conduction nor convection can occur in a vacuum. There are no molecules to transfer heat.
7 In a vacuum flask, hot things can be kept hot for long periods. Escape of heat is prevented.
8 Cold things can be kept cold for long periods in a vacuum flask. Heat from outside is kept out.
9 Heat can be preserved for long periods. Very little heat is lost by radiation.
10 A little heat can still escape from a vacuum flask. The vacuum and the insulation are never quite complete.

Exercise 3 Fill in the blank in each sentence, choosing the correct word from this list. (Use each word once only):

(a) exterior	(f) preserved	(k) radiation
(b) conduction	(g) convection	(l) consists
(c) silvered	(h) escape	(m) prevent
(d) penetrate	(i) reflected	(n) allowing
(e) interior	(j) extracted	

1 A vacuum flask —— of two very thin walls of glass.
2 Since the walls are ——, heat cannot —— the flask from the outside.
3 In order to —— the heat from escaping from the ——, the walls are silvered.
4 Because of the vacuum between the two glass walls, heat cannot —— by —— or by ——.
5 Heat can travel through a vacuum by ——.
6 The heat of hot things in the flask can be —— for long periods.

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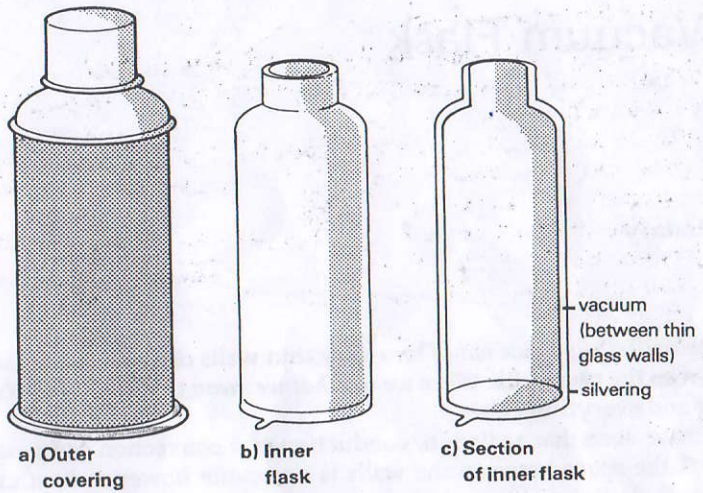

Vacuum flask

7 A vacuum exists between the two glass walls because the air and everything else has been ——.
8 Both the interior and the —— of the glass walls are silvered.
9 The silvered surfaces —— the heat back into the flask rather than —— it to escape.

Exercise 4 Rewrite this passage using passive forms. You will then have summarized the Texts. (The subjects of the passive sentences are italicised):

We have removed *the air and everything else* from between the two thin glass walls, so that conduction and convection cannot carry *the heat* away. We silver *the interior of the glass walls*. We do *this* to prevent loss of heat by radiation. Thus we lose *very little heat* by radiation. We can keep *hot things* hot and we can keep *cold things* cold for long periods. Thus we can use *a vacuum flask* for keeping heat in or for keeping it out.

Exercise 5 Answer these questions without referring to the Texts:

1 What does a vacuum flask consist of?
2 Where is the vacuum?
3 How is loss of heat by radiation, by conduction and by convection prevented?
4 How does silvering help to prevent loss of heat?
5 For what two purposes may a vacuum flask be used?

ercise 6 Questions for further discussion:

1 Why should central-heating radiators be dark in colour?
2 Which would keep water hot for longer, a shiny chromium jug or a dull chromium jug?
3 Why does an electric fire have a polished and curved surface behind it?
4 Where can a small amount of heat still escape from a vacuum flask such as the one we use on picnics?
5 When keeping things cold in a vacuum flask, why doesn't it matter very much if you leave the lid off?
6 When keeping things hot in a vacuum flask, why should the lid be kept on?
7 In summer, why are white clothes more comfortable to wear than dark-coloured clothes?

Vocabulary
curved jug

rcise 7 Suggestions for further activities:

1 Fill a vacuum flask and an ordinary bottle with very hot water. Close the neck of each, and leave side by side for a few hours. Which has lost more heat?
2 Take four ice-cubes of the same size. Put two into a vacuum flask and two into an ordinary jam-jar. Leave side by side for about 15 minutes. Which cubes have melted first?
3 Get three empty tins of the same size and paint the outside of one of them black. Paint another white, and leave the third unpainted. Put an equal amount of cold water and a thermometer into each. Place the three tins an equal distance from a source of heat, e.g. a fire, radiator or stove. Record the temperature of the water in each tin once every five minutes for half an hour. Which becomes hotter sooner? Which is the least hot? Why?

Revision Exercises V (Units 19–22)

I Give the meaning of these words in your own language:

1	wave	5	wool	9	silver
2	material	6	movement	10	current
3	crystal	7	vessel	11	shiny
4	to dip	8	mainly	12	asbestos

II Explain the meaning of:

1	the interior is silvered	6	this is not the case
2	it encloses air	7	heat is reflected
3	a poor heat conductor	8	convection currents
4	heat can be preserved	9	chemical formula: $KMnO_4$
5	by this is meant . . .	10	all other objects

III Give ONE word meaning:

1	easily and quickly	6	getting away
2	a liquid or a gas	7	at exactly the same time
3	in the same way	8	to stop from happening
4	a completely empty space	9	cannot be seen
5	movements of water	10	put the main ideas into a few words

IV Answer these questions without referring to the Texts:

1 In which directions does a fluid move when heated?
2 By which method can heat be transferred through a vacuum?
3 By which method is heat transferred in a solid?
4 Which absorbs more heat rays, a polished or a dull surface?
5 Give one example each of a good and a poor heat conductor.
6 What is a poor heat conductor frequently known as?
7 Why are the glass walls of a vacuum flask silvered?
8 Is a good conductor also a good insulator? (Give a reason for your answer.)

V Find the correct word with which to complete each of these sentences:

1 A polished surface —— more heat than a dull one.
(a) absorbs (b) encloses (c) reflects (d) extracts

2 Any material which —— air is a good heat insulator.
(a) encloses (b) absorbs (c) extracts (d) transfers
3 Heat is readily —— in all metals.
(a) absorbed (b) conducted (c) prevented (d) insulated
4 Convection currents are found mainly in ——.
(a) vacuums (b) flasks (c) fluids (d) crystals
5 Transfer of heat from one molecule to the next is known as ——.
(a) reflection (b) convection (c) radiation (d) conduction
6 The glass walls of a vacuum flask are silvered to prevent heat from —— by radiation.
(a) preserving (b) escaping (c) extracting (d) reflecting
7 Heat is —— from the sun with electro-magnetic waves.
(a) existed (b) dipped (c) preserved (d) derived
8 The movements of a fluid when heated are known as —— currents.
(a) transfer (b) radiation (c) convection (d) combustion
9 Still air is one of the —— heat insulators.
(a) poorest (b) chemical (c) simultaneous (d) best
10 The only method by which heat can travel in a vacuum is by ——.
(a) conduction (b) insulation (c) radiation (d) convection

Vocabulary

Brackets indicate that the word or phrase occurs under Questions for Further Discussion.

accident
acid
(to affect)
alcohol
amount
area
artificial
asbestos

bacteria (pl.)
bacterium
to balance
band
(bare)
bean
(bellows)
to bend
berry
(blacksmith)
to blow
a body
to boil
(boiler)
(bomb site)
bowl
to breathe
breathing
bulb
burdock
(to burst)

(a capital)
carbohydrates
(carnation)
(central heating)
certain
a chance
chemical
a chemical
clinical
cloudy
coal
coconut
complicated
compound
condition
copper
cork
a cork
cotton-wool
(to creak)
to be crowded
to crush
crystal
cube
cucumber, squirting
current
(curved)

damp
dandelion
to decrease
(defrosting)
degree
to depend (on)
description