VENTILATION OF DOMESTIC NATURAL GAS APPLIANCES

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Why ventilation is important

All fuels need a certain amount of oxygen in order for **complete combustion**. Every cubic metre of natural gas needs around **ten** cubic metres of clean air to burn properly.

Lack of clean air causes **incomplete combustion**, where the poisonous gas **carbon monoxide** is produced in dangerous quantities.

Normative documents

BS 5440-2:2009 Flueing and ventilation for gas appliances of rated input not exceeding 70 kW net (1st, 2nd and 3rd family gases). Specification for the installation and maintenance of ventilation provision for gas appliances

BS 5871-3:2005 Specification for the installation and maintenance of gas fires, convector heaters, fire / back boilers and decorative fuel effect gas appliances

IGEM/G/11 The Gas Industry Unsafe Situations Procedure

The Building Regulations Part J (Heat Producing Appliances) 2010 and Approved Document J (reprinted 2015)

The Gas Safety (Installation and Use) Regulations 1998

Determining the Unsafe Situations category of incorrect ventilation

The Gas Industry Unsafe Situations Procedure states that if available ventilation is less than 90% of appliance requirements, or if ventilation provision is defective, the installation is **At Risk**.

More than one related At Risk fault can be upgraded to **Immediately Dangerous**.

Spillage of products of combustion into a room or internal space is **Immediately Dangerous**.

Types of gas appliance

In terms of ventilation there are **three** types of gas appliance, known as types A, B and C:

Type A (flueless) appliances take their combustion air from the room and release their products of combustion into the room.

Flueless gas cooker

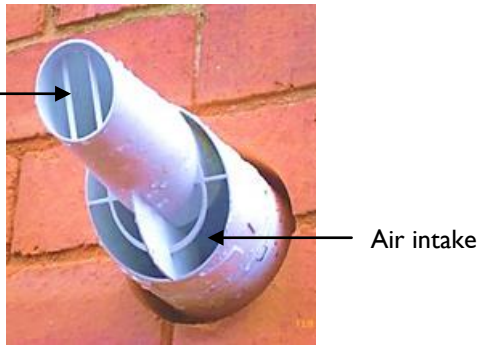
Flueless gas fire

Type B (open flue) appliances take their combustion air from the room and release their products of combustion to outside via a chimney or flue.

Open flue gas fire

Type C (room sealed) appliances take their combustion air from outside via an air intake, and release their products of combustion to outside via a flue.

Room sealed boiler



Concentric flue terminal

Heat input

The heat input of a gas appliance is effectively a measure of how much gas it burns in a given time. For certain appliances, heat input can be used to calculate the size of air vent required.

*Note: never use heat **output** for ventilation calculations. Heat output is a measure of the useful heat produced by an appliance, not of the amount of gas it consumes.*

All calculations in these notes are based on **net heat input** measured in **kilowatts (kW)**. Heat input can be found on the appliance data badge or in the manufacturer's instructions (MI).

Older appliances may specify **gross** heat input, or they may specify heat input in British Thermal Units (BTU) per hour. In some situations, heat input may not be given and **gas rate** specified instead. The table below can be used to convert these to net heat input in kilowatts:

Unit of measurement	Conversion to net heat input (kW)
kW (gross heat input)	÷ 1.1
BTU / h (gross heat input)	÷ 3787
m^3 / h (gas rate)	x 9.5
ft^3 / h (gas rate)	x 0.27

Conversions to net heat input (kW)

Converting to net heat input (kW) – examples

1. The data badge of a 1980s open flue boiler states that the heat input is 24 kW.

The badge does not specify "net" heat input, and the appliance is old, so we may assume heat input is gross. Using the conversion table, net heat input = 24 ÷ 1.1 = 21.8 kW.

2. The MI for an open flue water heater specifies its heat input as 33,000 BTU / h.

Using the conversion table, net heat input = 33000 ÷ 3787 = 8.7 kW.

3. The gas rate of an appliance is measured at 2.61 cubic metres per hour.

Using the conversion table, net heat input = 2.61 x 9.5 = 24.8 kW.

Ventilation of open flue appliances

Manufacturer's instructions (MI) will specify the appliance ventilation requirements. If MI are not available, ventilation for an open flue appliance can be calculated as:

Vent size (cm^2) = Net heat input (kW) x 5

*Note: this formula does not apply to **decorative fuel effect** appliances (see below).*

Adventitious air

In older, unrenovated houses a significant amount of **adventitious air** comes in through gaps and cracks around window frames, door frames, and floorboards. Where adventitious air is available, the calculated vent size for open flue appliances can be reduced by **35 cm^2** per room.

Properties built after 2002 and renovated properties may have double glazing and improved draught-proofing which reduces or eliminates adventitious air. A gas engineer must make an informed decision whether adventitious air is available or not on site.

Note: reducing vent size by 35 cm^2 is equivalent to subtracting 7 kW from appliance heat input. Open flue gas fires of heat input 7 kW or lower therefore do not need an air vent in rooms where adventitious air is available.

Decorative Fuel Effect (DFE) appliances

A DFE is a type of open flue gas fire in the form of a basket of ceramic radiants made to look like coal, wood, or stone. The basket is placed inside / under an open chimney. Unlike inset live fuel effect (ILFE) fires, DFEs do not have a convector or heat exchanger above the radiant bed.

Most DFEs need an air vent of **100 cm^2** regardless of their heat input. This figure already has the adventitious allowance taken off and should not be reduced further. Air vents for DFEs should not be situated inside the chimney.

DFE

ILFE (not a DFE)

Open flue ventilation – worked examples

1. A living room in a newly-built house contains an open flue gas fire of heat input 6.5 kW net

6.5 x 5 = 32.5 cm^2 permanent air vent required.

There is no allowance for adventitious air in a new-build house.

2. A kitchen in an unrenovated house built in 1989 contains an open flue boiler of 26 kW net

26 x 5 = 130 cm^2

Assuming adventitious air is available, 130 – 35 = 95 cm^2 permanent air vent required.

3. A room in an unrenovated house built in 1983 contains a DFE

100 cm^2 permanent air vent required.

There is no adventitious allowance for DFEs.

4. A bedroom of a renovated 1970s house contains an open flue gas fire of 6.6 kW gross

6.6 kW gross ÷ 1.1 = 6.0 kW net

6.0 x 5 = 30 cm^2 permanent air vent required.

The house has been renovated so we assume there is no adventitious allowance.

Ventilation of flueless appliances

Manufacturer's instructions (MI) will specify appliance ventilation requirements. If MI are not available, a flueless ventilation chart may be used:

Appliance	Max. net heat input permitted	Room volume	Vent size required	Openable window or equivalent needed?
Cooker, grill or hotplate	No maximum specified	< 5 m^3	100 cm^2	YES
		5 to 10 m^3	50 cm^2 needed if there is no door to outside No vent needed if there is a door to outside	
		> 10 m^3	No vent required	
Instantaneous water heater	11 kW	< 5 m^3	Installation not permitted	YES
		5 to 10 m^3	100 cm^2	
		> 10 to 20 m^3	50 cm^2	
		> 20 m^3	No vent required	
Fire in a habitable room	0.045 kW / m^3	Minimum 22.22 m^3 / kW	≤ 2.7 kW = 100 cm^2 > 2.7 kW = (Heat input – 2.7) x 55 + 100 cm^2	YES
Fire in a hallway, landing etc.	0.090 kW / m^3	Minimum 11.11 m^3 / kW	≤ 5.4 kW = 100 cm^2 > 5.4 kW = (Heat input – 5.4) x 27.5 + 100 cm^2	YES

Ventilation chart for flueless gas appliances

Note 1: do not use this chart for open flue appliances.

Note 2: the ***maximum heat input*** *column gives details of restrictions which apply to certain types of flueless appliance. For example, flueless gas fires shall have a maximum net heat input of 0.045 kW per cubic metre of room space.*

Note 3: there is no adventitious air allowance for flueless appliances.

Note 4: flueless appliances need an openable window to outside or equivalent (e.g. extractor fan) for human comfort. The user can open the window or turn on the extractor if the room becomes hot, stuffy or humid because of emissions from the appliance.

Note 5: flueless appliance ventilation should come directly from outside, either through an air vent on an outside wall or via a duct.

Flueless ventilation – worked examples

1. A kitchen of 12 m^3 contains a flueless water heater of 8 kW net heat input.

From the chart, a 50 cm^2 permanent vent and an openable window are required.

2. A room of 9 m^3 with no door to outside contains a flueless cooker.

From the chart, a 50 cm^2 permanent vent and an openable window are required.

3. A flueless space heater of heat input 3.1 kW (net) is to be installed in a living room of 70 m^3.

First, determine whether the room size is acceptable for the fire. From the chart, the room size must be at least 3.1 x 22.22 = 68.9 m^3. The room is big enough.

According to the flueless chart, the vent size is:

(Heat input – 2.7) x 55 + 100

= (3.1 – 2.7) x 55 + 100

= 0.4 x 55 + 100

= 122 cm^2 plus an openable window required

4. While performing a landlord's safety check you encounter a flueless gas fire of net heat input 3.0 kW installed in a living room of 36 m^3. You measure the room air vent as 100 cm^2.

From the chart, the room size must be at least 3.0 x 22.22 = 66.7 m^3. The room is too small for the appliance. This should be classed as an At Risk situation.

The vent size should be (3.0 – 2.7) x 55 + 100 = 116.5 cm^2. The room vent is less than 90% of the required size (100 ÷ 116.5 x 100 = 85.8%) so this is a second At Risk situation.

Two related At Risk situations may be upgraded to Immediately Dangerous.

5. A flueless water heater of net heat input 13 kW is installed in a kitchen of 40 m^3.

From the chart, we see that the water heater's heat input is over the 11 kW limit and is therefore not permitted. This should be treated as an At Risk situation.

Ventilation of rooms containing more than one appliance

Where there is more than one open flue or flueless gas appliance in a room, the overall ventilation requirement is the **largest** of either:

- The total ventilation requirement of all **open flue space heaters**, or
- The total ventilation requirement of all **flueless space heaters**, or
- Any other individual ventilation requirement

Note 1: "space heaters" means appliances designed to heat living spaces such as fires, ducted air heaters and central heating boilers. Appliances such as cookers and water heaters are not space heaters. Although they heat the room via heat wastage, this is not their purpose.

*Note 2: when calculating the ventilation requirement of open flue space heaters, take off any adventitious allowance only **once** from the total requirement, not for each individual appliance.*

Multi-appliance ventilation – worked examples

1. A kitchen of 18 m^3 in an unrenovated 1990s house contains:

a) a flueless water heater of net heat input 8.5 kW
b) an open flue central heating boiler of net heat input 28 kW
c) an open flue gas fire of net heat input 5 kW

From the flueless chart, appliance a) requires 50 cm^2 and an openable window.

Appliance b) requires 28 x 5 = 140 cm^2

Appliance c) requires 5 x 5 = 25 cm^2

Appliances b) and c) are both open flue space heaters, so add them: 140 + 25 = 165 cm^2

Adventitious air is available: 165 – 35 cm^2 = 130 cm^2

The largest requirement is for the open flue space heaters, so the room requires a 130 cm^2 air vent. An openable window is needed because there is a flueless appliance in the room.

2. A kitchen of 20 m^3 in an unrenovated 1950s house contains:

a) **a flueless cooker**
b) **an open flue boiler of net heat input 26 kW**
c) **a flueless water heater of net heat input 10 kW**
d) **an open flue gas fire of net heat input 6 kW**

From the flueless chart, appliance a) does not require purpose-provided ventilation but it does require an openable window.

Appliance b) requires 26 x 5 = 130 cm^2

From the flueless chart, appliance c) requires 50 cm^2 and an openable window.

Appliance d) requires 6 x 5 = 30 cm^2

Appliances b) and d) are both open flue space heaters, so add them: 130 + 30 = 160 cm^2

Adventitious air is available, so 160 – 35 = 125 cm^2

The largest requirement is for the open flue space heaters, so the room needs a 125 cm^2 air vent. An openable window is needed because there are flueless appliances in the room.

3. A room of 70 m^3 contains:

a) **a DFE of net heat input 5.6 kW**
b) **a flueless gas fire of net heat input 2.9 kW**

Appliance a) needs 100 cm^2

According to the flueless ventilation chart, the room size for appliance b) should be at least 2.9 x 22.22 = 64.4 m^3. The room is big enough.

The vent required for appliance b) is (2.9 – 2.7) x 55 + 100 = 111 cm^2

Both a) and b) are space heaters but are not of the same flue type so their ventilation requirements remain separate.

The larger requirement is for appliance b), so the room needs an air vent of 111 cm^2. An openable window is needed because there is a flueless appliance in the room.

Air vents

Where required, ventilation for gas appliances shall be provided by air vents which:

- are rigid
- are not closable
- do not have a fly-screen
- do not have openings narrower than 5 mm

To prevent the entry of pests, vents to outside should have openings no wider than 10 mm.

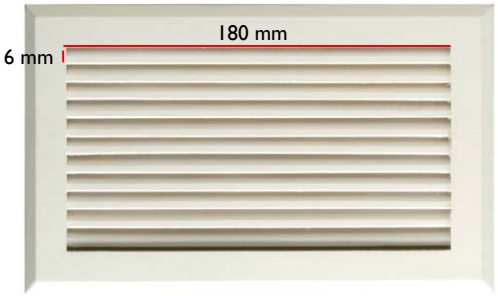
Measuring an air vent

Most new air vents are marked with the amount of **free area** they provide. Free area is the total area open to the air source. If free area is not given it can be measured as follows:

Each opening = 180 mm x 6 mm = 1080 mm^2

Total free area = 1080 x 11 openings = 11880 mm^2

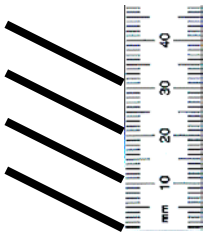
Convert to cm^2 = 11880 ÷ 100 = 118.80 cm^2



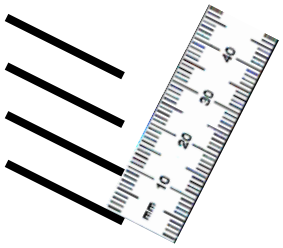
Vents with angled louvres

If a vent has angled or sloping louvres like the one above, it is important to measure the width of the openings correctly. Use a steel rule to measure at right angles to the louvre (as shown in the right-hand diagram below). The base of the rule should rest flat on the louvre. Measure the air gap only; do not include the thickness of the louvre.

Angled louvres



Incorrect measurement
= 10 mm



Correct measurement
= 7 mm

Air bricks

Terracotta air bricks are an acceptable form of air vent but their free area is relatively small. They are often used in a supplementary role with other types of vent.

8 mm bit passes through completely.
9 mm bit does not pass through.
∴ Inner hole = 8 mm x 8 mm

Many air bricks have holes which taper internally, with the visible outer side having larger openings than inside the wall cavity. Free area must be calculated from the smaller side, making measurement difficult. This problem can be solved by using a tapered measuring device or by inserting drill bits of increasing diameter.

Intumescent air vents

An intumescent vent permanently closes in the event of a fire. When overheated, a special material inside the vent expands greatly to block air flow and to prevent the spread of smoke and fire.

Intumescent vents may be needed in order to comply with a fire risk assessment. Once activated, they must be replaced with a new intumescent air vent of the same free area.

Ventilation of appliances in compartments

Open flue and room sealed appliances may be installed in compartments for decorative purposes. Appliance compartments should not be used for any other purpose (e.g. airing linen), and there should be a label warning the householder not to block vents.

Compartments containing open flue appliances shall be ventilated for combustion air and cooling. Compartments containing room sealed appliances *may* need ventilation for cooling. Consult manufacturer's instructions for guidance.

Compartment vents shall be at both high and low level. The low-level vent allows the entry of cool air. The high-level vent allows the removal of warm air by convection.

High- and low-level vents should communicate with the same internal space or outside wall. Otherwise there is the possibility of **cross-ventilation** where unequal air pressures create draughts potentially harmful to the operation of the appliance.

If MI are unavailable, the following table can be used to size compartment vents:

Vent size (cm^2 per kW)	Open flue		Room sealed	
	Vents to outside	Vents to room	Vents to outside	Vents to room
High level	5	10	5	10
Low level	10	20	5	10

Compartment vent size table

Ventilation may be ducted into a compartment from a ventilated roof space. Separate ducts shall be provided to high and low level. The cross-sectional area of ducts shall be at least equal to the area of the vents they serve. A ventilated roof space may be considered as outside air if it is sufficiently ventilated (see BS 5250) but otherwise should be treated as an internal space.

In the case of an open flue appliance in a compartment vented to a room, the room must be ventilated according to the usual requirements of the appliance.

Compartments shall not be used to house open flue appliances in a bathroom or shower room. Compartment air vents shall not communicate with a bathroom or shower room.

Note: there is no allowance for adventitious air in compartment vent sizing.

Compartment ventilation – worked examples

1. A room sealed boiler of 28 kW net heat input is installed in a compartment with air vents communicating directly to outside air.

From the table, the compartment requires:

28 x 5 = 140 cm^2 at high level

28 x 5 = 140 cm^2 at low level

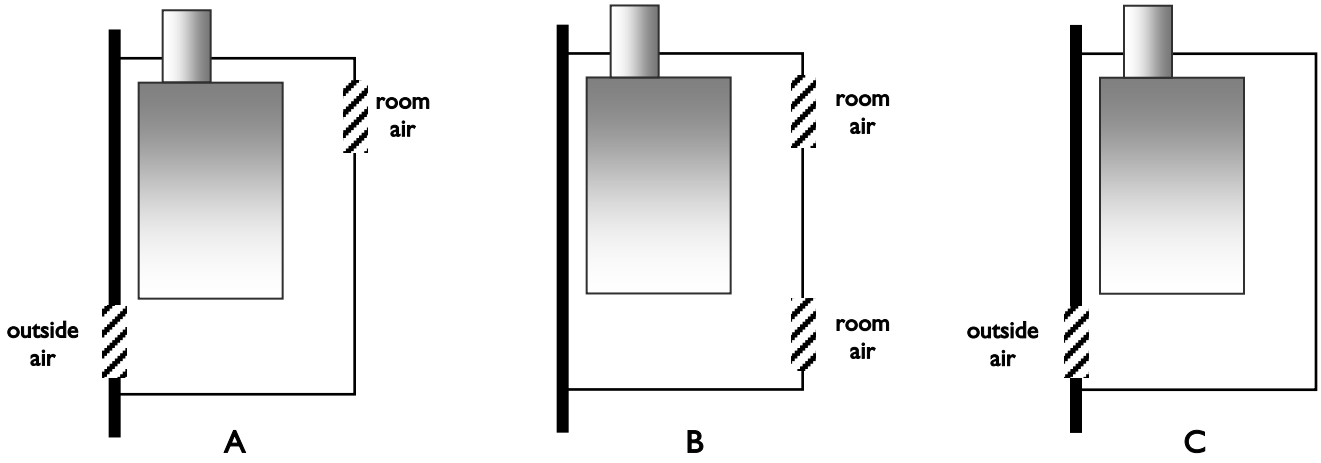
2. An open flue water heater of 18 kW net heat input is installed in a compartment with air vents communicating with a kitchen.

From the table, the compartment requires:

18 x 10 = 180 cm^2 at high level

18 x 20 = 360 cm^2 at low level

3. Are the following compartment installations acceptable or not?

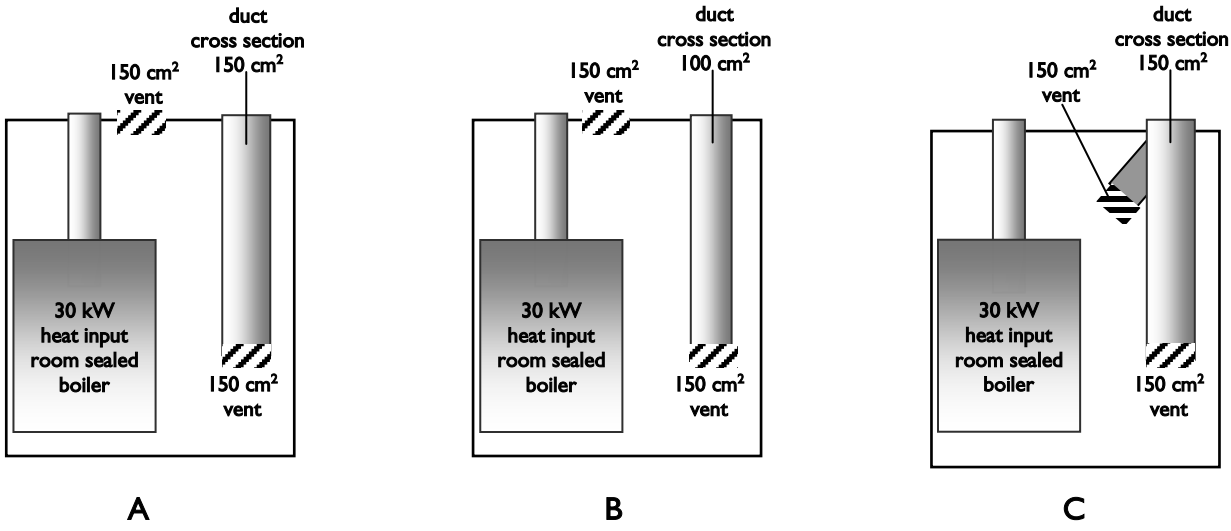


A – Unacceptable: vents are communicating with different spaces.

B – Acceptable

C – Unacceptable: no high-level ventilation is provided.

4. Are the following compartment installations, in which ventilation is ducted from a well-ventilated roof space, correctly ventilated or not?



A – Correct

B – Incorrect. Cross-sectional area of duct is smaller than the vent size.

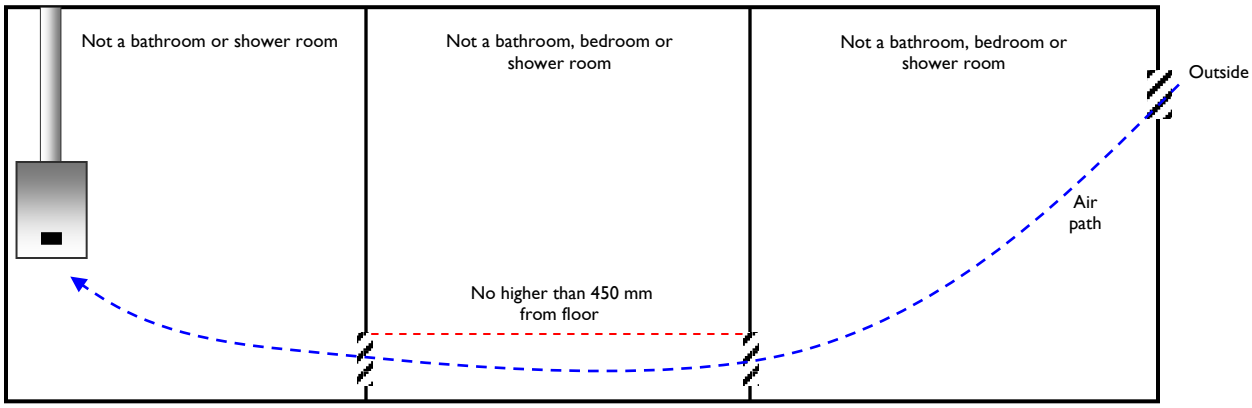
C – Incorrect. Inlet and outlet vents cannot share a duct.

Indirect ventilation through adjoining rooms

If there is nowhere to put an air vent directly to outside, ventilation for open flue appliances may be taken from an adjoining room or through a series of rooms.

Note: for flueless appliances requiring ventilation, air shall be taken directly from outside or be ducted from outside.

If the air path passes through more than one internal wall, all internal air vents should be 1.5 times bigger than the external vent (which is sized normally). The air path cannot pass through a bathroom, shower room or bedroom. Internal air vents should be positioned no higher than 450 mm from the floor in order to slow the passage of smoke and poisonous gases in the event of a fire.



Indirect ventilation

Worked example

An open flue water heater of heat input 15 kW net is installed in the kitchen of a renovated house. Ventilation is to be taken through two adjoining rooms. Calculate the size of the external vent and the two internal vents, stating any positional requirements.

External vent: 15 kW x 5 = 75 cm^2

Internal vents: both internal vents will be 75 x 1.5 = 112.5 cm^2, no higher than 450 mm from floor level.

Glossary

Adventitious air	Air entering a room through gaps in door and window frames, etc.
Air vent	An open grille designed to allow air into a room
Carbon	An element; produced by **incomplete combustion** as soot
Carbon monoxide	A highly-poisonous, colourless, odourless gas
Carbon dioxide	One of the **products of combustion** of **gas**
CO	Chemical formula of **carbon monoxide**
CO_2	Chemical formula of **carbon dioxide**
Combustion air	Air used for the combustion of **gas**
Compartment	A cupboard or housing for a gas appliance
Complete combustion	**Gas** burned with enough **oxygen** to produce negligible **CO**
Flue	The chimney of a gas appliance
Free area	The total area of the openings in an **air vent**
Gas	1. A substance in the gaseous state 2. Short for **natural gas**
Heat input	A measure of the **gas** usage of an appliance
Hydrocarbon	A compound made up of only hydrogen and **carbon**
Incomplete combustion	**Gas** burned with too little **oxygen**, producing **carbon monoxide**
Intumescent air vent	A special type of **vent** which permanently closes if there is a fire
Methane	A **hydrocarbon** fuel gas with the chemical formula CH_4
Natural gas	The mains gas used in the UK; composed mostly of **methane**
Oxygen	The active part of air that supports combustion
Products of combustion	The exhaust gases produced by a gas appliance
Space heater	An appliance designed to heat living spaces
Vent	An **air vent**
Ventilation	The provision of **combustion air** or cooling air to a gas appliance
Ventilator	An **air vent**
Vitiation	The contamination of **combustion air** by **products of combustion**