

FUEL AND ITS CHARACTERISTICS

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LECTURE IN AUTOMOTIVE ENGINEERING

UMMGL

TOPICS TO BE COVERED

- FUEL
- COMBUSTION OF FUEL
- CLASSIFICATION OF FUEL
- CALORIFIC VALUE
- CHARACTERISTICS OF GOOD FUEL
- REVIEW OF TOPIC IN TERMS OF MULTIPLE CHOICE QUESTIONS

FUEL

The combustible substances which on burning in air produces large amount of heat that can be used economically for domestic and industrial purposes are called fuels.

Eg. Wood ,Coal etc

COMBUSTION OF FUEL

The term combustion refers to the exothermal oxidation of a fuel, by air or oxygen occurring at a sufficiently rapid rate to produce a high temperature, usually with the appearance of a flame.

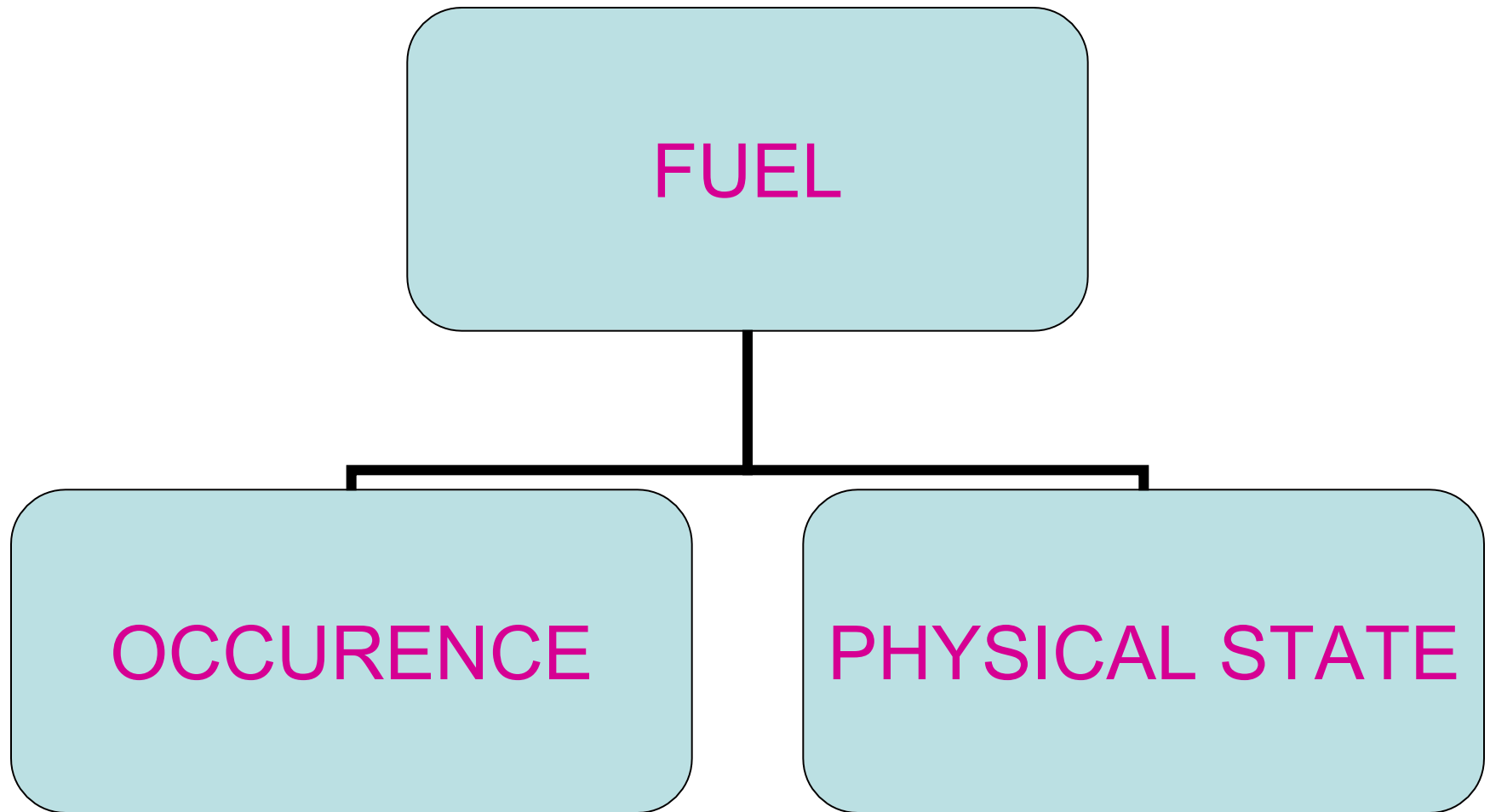
As most of the fuels contain carbon or carbon and hydrogen, the combustion involves the oxidation of carbon to carbon dioxide and hydrogen to water. Sulphur, if present, is oxidised to sulphur dioxide while the mineral matter forms the ash. Complex fuels like coal undergo thermal decomposition during combustion to give simpler products which are then oxidised to carbon dioxide, water etc.

e.g.: **Coke** on combustion gives carbon dioxide

Coal \rightarrow Coke + Coal gas

C (coke) + O₂ \rightarrow CO₂

CLASSIFICATION OF FUEL



On the basis of occurrence

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graph TD; FUEL[FUEL] --- PRIMARY[PRIMARY OR NATURAL FUEL]; FUEL --- SECONDARY[SECONDARY OR ARTIFICIAL FUEL];
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FUEL

PRIMARY OR
NATURAL FUEL

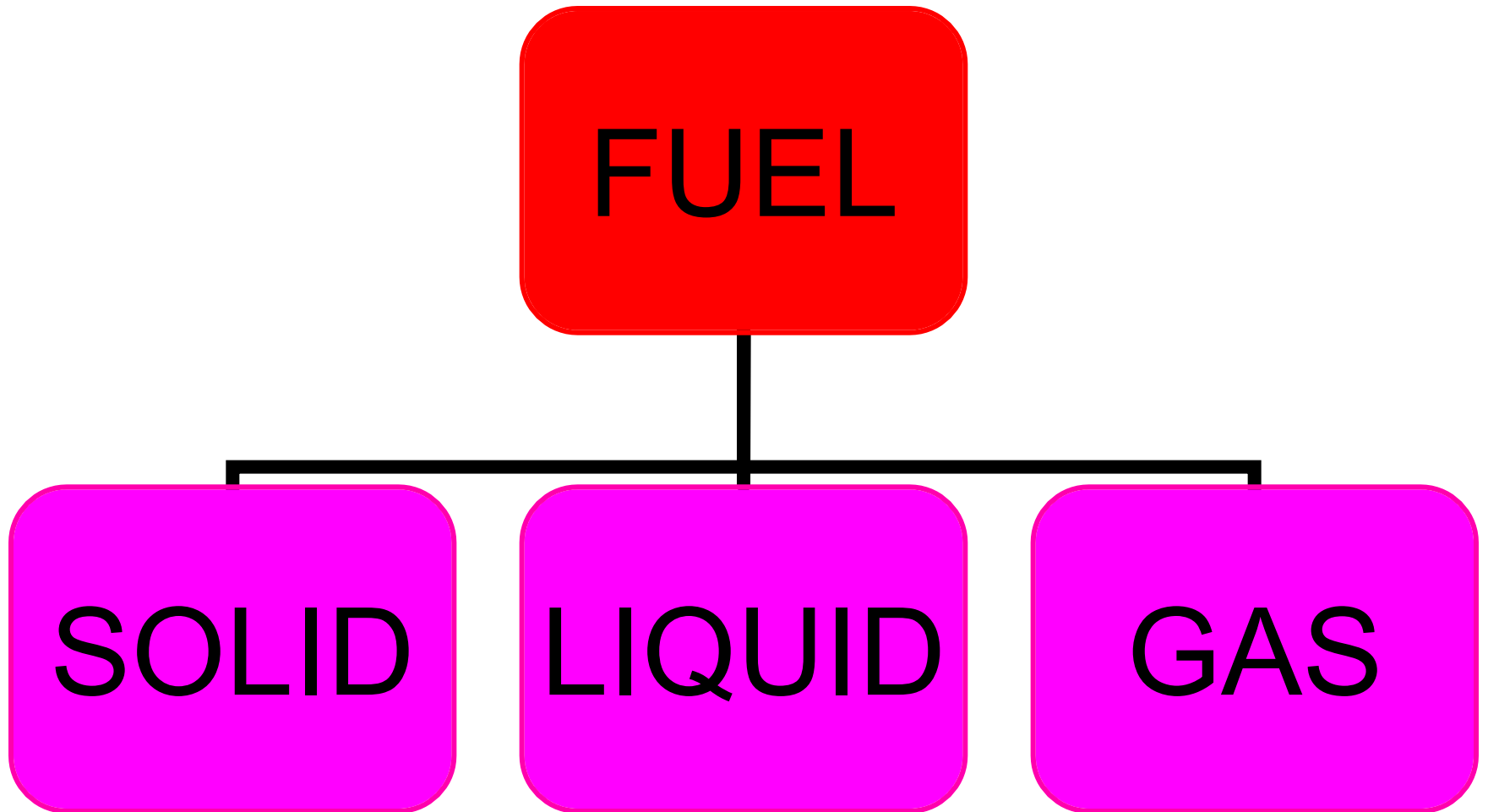
SECONDARY OR
ARTIFICIAL FUEL

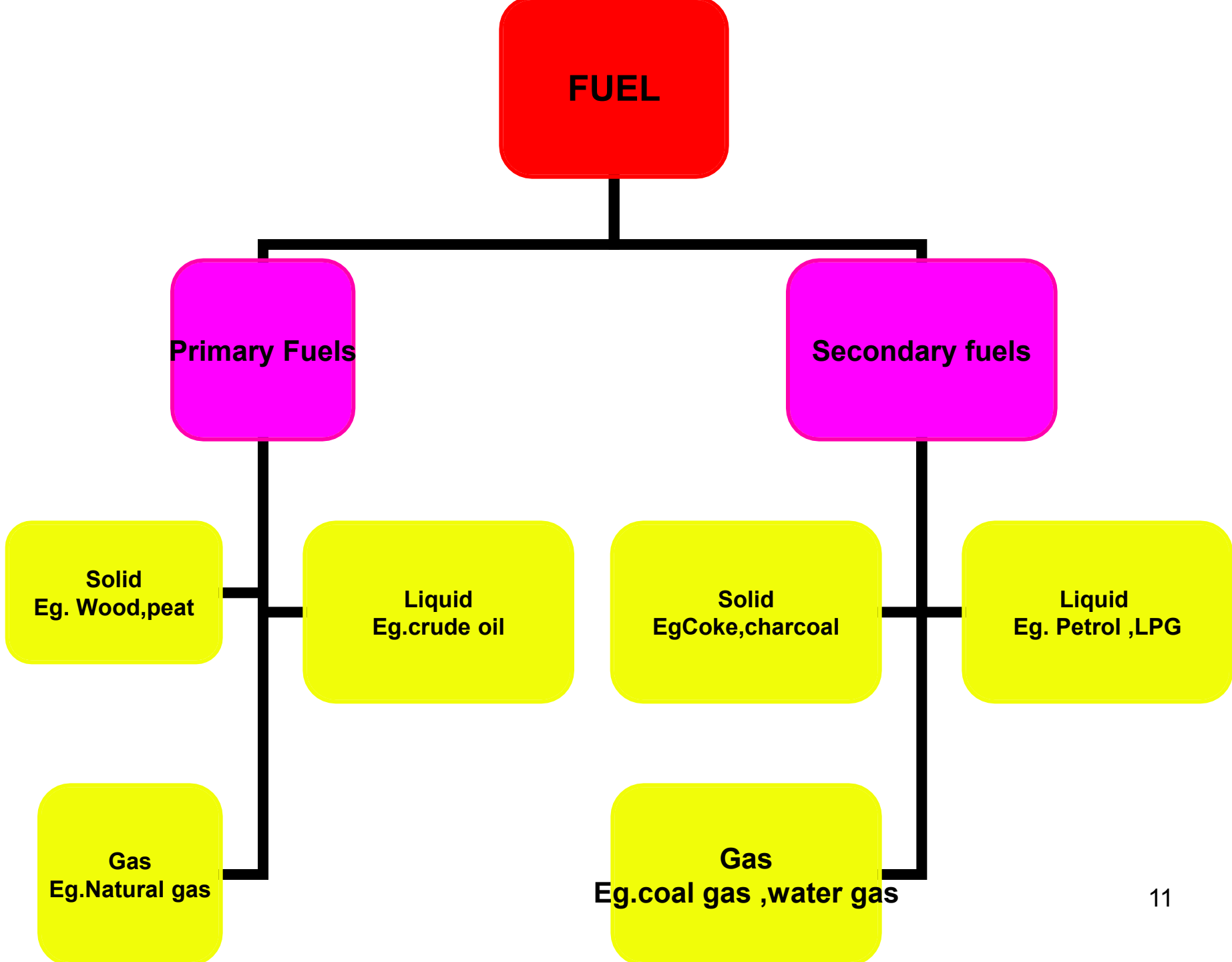
CLASSIFICATION OF FUEL

Fuels are classified as

- Primary fuels – Fuels which occur naturally such as coal, crude petroleum and natural gas. Coal and crude petroleum, formed from organic matter many millions of years ago, are referred to as fossil fuels.
- Secondary fuels – Fuels which are derived from naturally occurring ones by a treatment process such as coke, gasoline, coal gas etc.

On basis of physical state





CHARACTERISTICS OF GOOD FUEL

1.HIGH CALORIFIC VALUE:

A good fuel should have high calorific value i.e. it should produce large amount of heat on burning.

CALORIFIC VALUE

The calorific value of a fuel is defined as the quantity of heat (expressed in calories or kilo calories) liberated by the complete combustion of unit weight (1gm or 1kg) of the fuel in air or oxygen, with subsequent cooling of the products of combustion to the initial temperature of the fuel.

contd

The calorific value of a fuel depends upon the *nature of the fuel* and the *relative proportions of the elements* present, increasing with increasing amounts of hydrogen. Moisture if present, considerably reduces the calorific value of a fuel. The calorific value may be theoretically calculated from the chemical composition of the fuel.

If both hydrogen and oxygen are present, it may be assumed that all the oxygen are already combined with $1/8$ of its weight of hydrogen to form water. This fraction is then deducted from the hydrogen content of the fuel in the calculation. Thus for a fuel containing carbon, hydrogen, oxygen and sulphur, the calorific value of the fuel is given by **DULONG FORMULA**

Determination of calorific value from Dulong formula

Calorific value =

$$1/100[8080 C + 34500 \{H - O/8\} + 2240 S] \text{ kcal/kg}$$

where C, H, O, S refer to % of carbon, hydrogen, oxygen and sulphur respectively.

GROSS AND NET CALORIFIC VALUE

With fuels containing hydrogen, two calorific values are distinguished, *the gross and the net calorific value*.

GROSS CALORIFIC VALUE

The gross calorific value refers to the heat evolved when the water produced by combustion is condensed as a liquid. The net value gives the heat liberated when water is in the form of steam or water vapour.

contd

Thus the gross calorific value (or the higher heating value) is the quantity of heat liberated by the complete combustion of unit weight of the fuel with subsequent cooling of the products of combustion to the initial temperature of the fuel.

NET CALORIFIC VALUE

Under normal working conditions, water vapours produced during combustion are not condensed and escape as such along with the hot gases. Hence lesser amount of heat is available, which is called Lower or net calorific value.

Contd.

Net calorific value is the heat produced when unit mass of fuel is burnt completely and products of combustion are allowed to escape.

The net calorific value (or the lower heating value) is defined as the gross calorific value minus the latent heat of condensation of water (at the initial temperature of the fuel), formed by the combustion of hydrogen in the fuel. The latent heat of steam at ordinary temperature may be taken as 587 cal/g

Net calorific value=Gross calorific value-Latent heat of water vapours

NCV=GCV-weight of hydrogen x 9 x Latent heat of water vapours

Latent heat of water vapours is 587 kcal/kg

Calculation of Net calorific value

Hydrogen in the fuel reacts with oxygen to give water



$$2\text{parts} = 16\text{parts} = 18\text{parts}$$

$$1\text{parts} = 8\text{parts} = 9\text{parts}$$

Contd

Let H is the percentage of hydrogen in the fuel

Amount of water produced by burning unit mass of fuel = $9H/100$ g

Latent heat of steam = 587 cal/g

Amount of heat produced by condensation of steam = $9H/100 \times 587$ cal

$$\begin{aligned} \text{NCV} &= [\text{GCV} - 9H/100 \times 587] \\ &= [\text{GCV} - 0.09 \times 587] \text{ cal/g} \end{aligned}$$

2. MODERATE IGNITION

TEMPERATURE:

Ignition temperature: the lowest temperature to which fuel must be preheated so that it starts burning smoothly. If ignition temp. is low, the fuel catches fire easily. Low ignition temperature is dangerous for storage and transportation of fuel. High temperature causes difficulty in kindling. So ,a good fuel should have moderate ignition temperature.

3. LOW MOISTURE CONTENT:A

good fuel should have low moisture content as moisture content reduces the calorific value.

4. LOW NON-COMBUSTIBLE MATTER CONTENT

A good fuel should have low contents of non-combustible material as non-combustible matter is left in form of ash which decreases the calorific value of fuel

5.MODERATE RATE OF COMBUSTION:

The temperature of combustion of fuel depends upon the rate of combustion . If the rate of combustion is low ,then required high temperature may not be reached soon. On the other hand ,too high combustion rate causes high temperature very quickly.

6.MINIMUM SMOKE AND NON-POISONOUS GASES

On burning, Fuel should not give out objectionable and poisonous gases. In other words, gaseous products should not pollute the atmosphere. Gases like CO , SO_2 , H_2S etc. are some of harmful gases.

7.CHEAP: A good fuel should be cheap and readily available.

8.EASY TRANSPORTATION :
A good fuel should be easy to handle and transport at low cost

9.CONTROLLABLE

COMBUSTION:

Combustion of fuel should be easy to start or stop when required.

10.NON SPONTANEOUS

COMBUSTION: Combustion of fuel should be non-spontaneous otherwise it can cause fire hazards.


Contd.

11.LOW STORAGE COST:A

good fuel should be easily stored at low cost.

Let us discuss few **multiple choice questions**

Que1. A good fuel possess:

- a. High ignition temperature
 - b. Moderate ignition temperature
 - c. High calorific value
 - d. Both (b) and (c)
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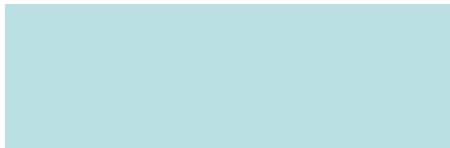
Que2. An example of primary fuel is :

a. wood charcoal


b. Coke

c. natural gas

d. petrol



Que3. The minimum temperature at which substance ignites and burns without further addition of heat from outside is called:

- a. ignition temperature
 - b. flash point
 - c. transition temperature
 - d. all the above
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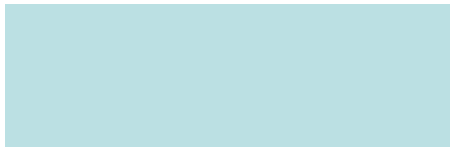
Que4. In a good fuel percentage of carbon is:

a. low

b. high

c. moderate

d. zero



Que5. Combustion of fuel involves chemical reaction between fuel and

a. Hydrogen

b. Nitrogen

c. Oxygen

d. Chlorine



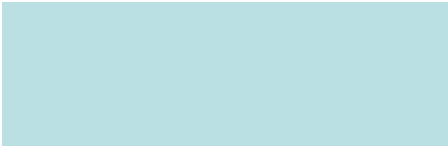
Que6. The reaction in which heat is absorbed is called

- a. Exothermic
- b. Endothermic
- c. Exegonic
- d. none of these

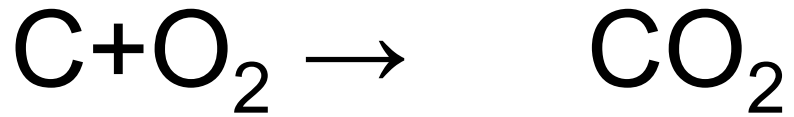


Que7. Fuel can be defined as a substance which produces heat by

- a. combustion
- b. Reduction
- c. None of these
- d. All of above



Que8. The combustion reaction



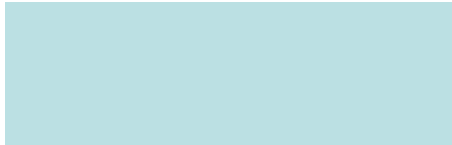
is

- a. Exothermic
- b. Endothermic
- c. Autocatalytic
- d. none of these




Que9. Which of following constituent of fuel does not contribute to its calorific value?

- a. hydrogen
- b. sulphur
- c. nitrogen
- d. None of these




Que10. A good fuel should have following characteristics:

- a. Moderate ignition temperature
- b. High calorific value
- c. Low moisture content
- d. all of these



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