Q.1) a) Discuss variouse pollutents emitted from CI engines,there causes & effect of mode of operation on them.

Carbon monoxide -63.91%

•Unburnthydrocarbons -22.51%

•Nitrogen oxides -11.75%

•Sulphuroxides -0.87%

•Organic and Inorganic lead components -2.3%

•Particulate -0.98%

b) Discuss in detail the mechanism of acid rain formation & its ill effects on the human life, crop property.

Acid rain is rain or any other form of precipitation that is unusually acidic, i.e. elevated levels of hydrogen ions (low pH). It can have harmful effects on plants, aquatic animals, and infrastructure through the process of wet deposition. Acid rain is caused by emissions of compounds of ammonium, carbon, nitrogen, and sulphur which react with the water molecules in the atmosphere to produce acids. Governments have made efforts since the 1970s to reduce the production of sulphuric oxide into the Earth's atmosphere with positive results. However, it can also be caused naturally by the splitting of nitrogen compounds by the energy produced by lightning strikes, or the release of sulfur dioxide into the atmosphere by volcano eruptions.

"Acid rain" is a popular term referring to the deposition of wet (rain, snow, sleet, fog and cloud water, dew) and dry (acidifying particles and gases) acidic components. A more accurate term is “acid deposition”. Distilled water, once carbon dioxide is removed, has a neutral pH of 7. Liquids with a pH less than 7 are acidic, and those with a pH greater than 7 are bases. “Clean” or unpolluted rain has a slightly acidic pH of about 5.2, because carbon dioxide and water in the air react together to form carbonic acid, a weak acid (pH 5.6 in distilled water), but unpolluted rain also contains other chemicals.[1]

$$H_2O\ (l) + CO_2\ (g) \rightarrow H_2CO_3\ (aq)$$

Carbonic acid then can ionize in water forming low concentrations of hydronium and carbonate ions:

$$2\ H_2O\ (l) + H_2CO_3\ (aq) \rightleftharpoons CO_3^{2-}\ (aq) + 2\ H_3O^+\ (aq)$$

Q.2) Expalin the variouse devices used in IC Engines to control air pollution

There are variouse divices used to control the air pollution such as Catlytic converter, ELCD, Crank case bloby, After burner, EGR etc.

1] Catalytic converter

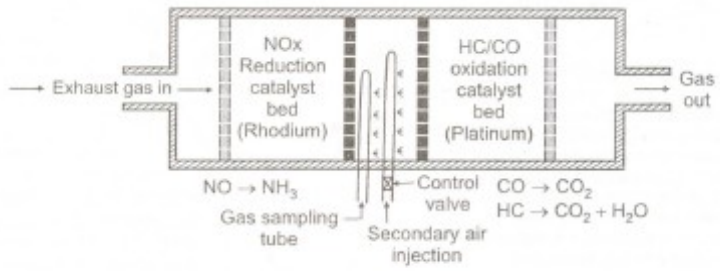


Fig. 23.32. Duel catalyst converter.

A **catalytic converter** (colloquially, "cat" or "catcon") is a device used to reduce the toxicity of emissions from an internal combustion engine. First widely introduced on series-production automobiles in the U.S. market for the 1975 model year to comply with tightening EPA regulations on auto exhaust, catalytic converters are still most commonly used in motor vehicle exhaust systems.

2] After Burner

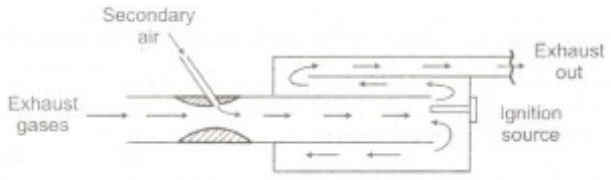


Fig. 23.27. (*a*) Typical after burner.

An **afterburner** (or **reheat**) is an additional component added to some jet engines, primarily those on military supersonic aircraft. Its purpose is to provide a temporary increase in thrust, both for supersonic flight and for takeoff (as the high wing loading typical of supersonic aircraft designs means that take-off speed is very high). On military aircraft the extra thrust is also useful for combat situations. This is achieved by injecting additional fuel into the jet pipe downstream of (i.e. *after*) the turbine.

3] EGR

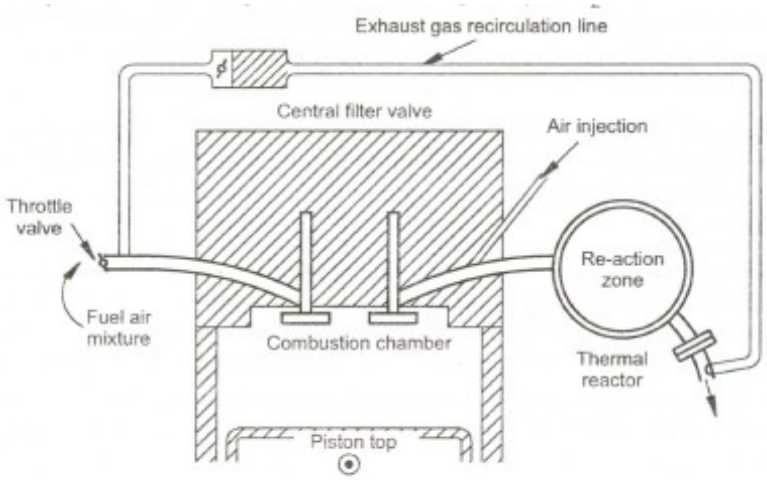


Fig. 23.40. EGR-System.

In internal combustion engines, exhaust gas recirculation (EGR) is a nitrogen oxide (NOx) emissions reduction technique used in most petrol/gasoline and diesel engines.
EGR works by recalculating a portion of an engine's exhaust gas back to the engine cylinders. In a gasoline engine, this inert exhaust displaces the amount of combustible matter in the cylinder. This means the heat of combustion is less, and the combustion generates the same pressure against the piston at a lower temperature.

4] Evaporative loss control device

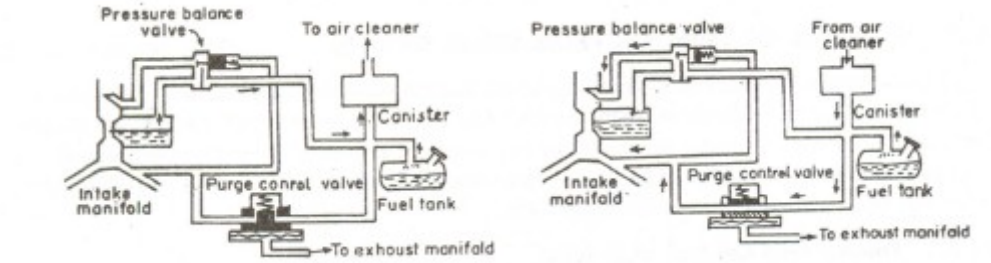
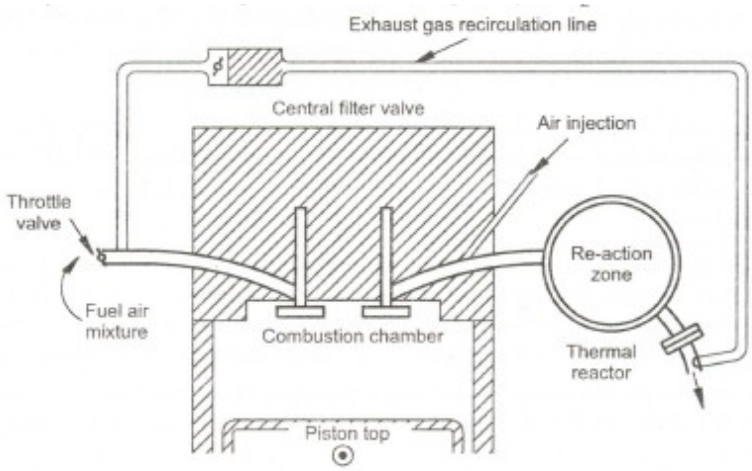


Fig. 23.43. Fuel-system evaporation loss control device.

An evaporation loss control device provided with a polymer chamber filled with polymer absorbent, a charcoal chamber filled with charcoal, introduction and purging pipes for connecting the polymer chamber with a fuel tank and an engine intake passage, respectively, an air pipe for ventilation connected to the charcoal chamber, and a vapor passage, which has various forms.

b) Discuss the variouse methods adopted to control & analysis the oxides of nitrogen in the automotive emission.
Many theoretical and experimental investigations have well established the fact that the concentration of NO *x* in the exhaust is closely related to the peak cycle temperature, and anything done to reduce this temperature will reduce the oxides of nitrogen. This suggests a number of potential methods for reducing the level of nitrogen oxides *(NOx).*
The following are the three methods which have been investigated so far:
(a) Exhaust gas recirculation (EGR).
(b) Water injection.
(c) Catalyst.
(a) Exhaust gas recirculation.' In Fi~. 20.20 is shown sch~mati~ly the exhaust gas recirculation system. A portion of the exhaust gas IS reclC~ulated to the cylinder intake charge. This reduces the peak combustion temperature, since the inert gas serves as a heat sink. This also reduc- es the quantity of oxygen available for combustion.



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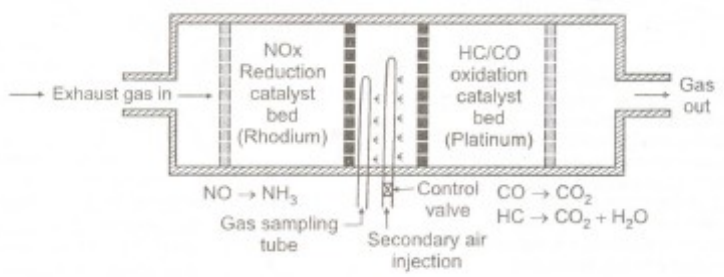
b) Water injection-

A process and apparatus for limiting the production of nitrogen oxides (NO_x) during the combustion of a fossil fuel (e.g. natural gas, fuel oil and coal) in a cyclone type boiler includes the injection of water into the secondary air supply. The water is quickly vaporized into steam as the temperature rises, simultaneously cooling the surrounding air predominately as a result of the latent heat of vaporization, thus reducing the quantity of heat contained within the combustion air delivered to the flame. To avoid quenching combustion, substantially all of the water is vaporized into steam prior to exiting the cyclone section. For natural gas and fuel oil, preferably about 2.5 to 10.0 gallons of water are injected per 100 lbs of fuel. Water is injected through existing ports originally provided in cyclone boilers either for use as secondary air calibration ports or as oil deslagging system ports. A plurality of V-jet type spray nozzles are utilized to achieve a uniform dispersion of water in the combustion air and to keep the droplet size small. The location of the nozzles is selected to maximize heat extraction from the flame, while not quenching the flame. A process control system may be utilized to inject a quantity of water proportional to the quantity of fuel fired, for single fuel and multiple fuel (e.g. both oil fuel and gas fuel) cyclone boiler fuel systems.

c) Catalytic converter



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Q.3) a) Discuss the alternative power plants which can be consider good from emission point of view.

An **alternative fuel vehicle** is a vehicle that runs on a fuel other than "traditional" petroleum fuels (petrol or diesel); and also refers to any technology of powering an engine that does not involve solely petroleum (e.g. electric car, hybrid electric vehicles, solar powered). Because of a combination of factors, such as environmental concerns, high oil prices and the potential for peak oil, development of cleaner alternative fuels and advanced power systems for vehicles has become a high priority for many governments and vehicle manufacturers around the world.

1) Air engine-

The air engine is an emission-free piston engine that uses compressed air as a source of energy. The first compressed air car was invented by a French engineer named Guy Nègre. The expansion of compressed air may be used to drive the pistons in a modified piston engine. Efficiency of operation is gained through the use of environmental heat at normal temperature to warm the otherwise cold expanded air from the storage tank. This non-adiabatic expansion has the potential to greatly increase the efficiency of the machine. The only exhaust is cold air (−15 °C), which could also be used to air condition the car. The source for air is a pressurized carbon-fiber tank. Air is delivered to the engine via a rather conventional injection system. Unique crank design within the engine increases the time during which the air charge is warmed from ambient sources and a two stage process allows improved heat transfer rates.

2) Battery-electric

Battery electric vehicles (BEVs), also known as all-electric vehicles (AEVs), are electric vehicles whose main energy storage is in the chemical energy of batteries. BEVs are the most common form of what is defined by the California Air Resources Board (CARB) as zero emission (ZEV) passenger automobiles, because they produce no tailpipe emissions while being

driven. The electrical energy carried onboard a BEV to power the motors is obtained from a variety of battery chemistries arranged into battery packs. For additional range genset trailers or pusher trailers are sometimes used, forming a type of hybrid vehicle. Batteries used in electric vehicles include "flooded" lead-acid, absorbed glass mat, NiCd, nickel metal hydride, Li-ion, Li-poly and zinc-air batteries.

3) Solar

A solar car is an electric vehicle powered by solar energy obtained from solar panels on the car. Solar panels cannot currently be used to directly supply a car with a suitable amount of power at this time, but they can be used to extend the range of electric vehicles. They are raced in competitions such as the World Solar Challenge and the North American Solar Challenge. These events are often sponsored by Government agencies such as the United States Department of Energy keen to promote the development of alternative energy technology such as solar cells and electric vehicles. Such challenges are often entered by universities to develop their students engineering and technological skills as well as motor vehicle manufacturers such as GM and Honda.

4) **Ammonia fuelled vehicles**

Ammonia GreenNH3 is being used with success by developers in Canada , since it can run in spark ignited or diesel engines with minor modifications,also the only green fuel to power jet engines,, and despite its toxicity is reckoned to be no more dangerous than petrol or LPG.[19] It can be made from renewable electricity, and having half the density of petrol or diesel can be readily carried in sufficient quantities in vehicles. On combustion it has no emissions other than nitrogen and water vapour.The Canadian group GreenGas dot cc have developed a machine to make the GreenNH3 from zero carbon energy sources so as not to have any link to carbon. That would be as opposed to brownNH3 which can be made from carbon things like coal or natural gas.

5) Bioalcohol / Ethanol

Both ethanol and methanol have been use as an automotive fuel.[24] While both can be obtained from petroleum or natural gas, ethanol has attracted more attention because it is considered a renewable resource, easily obtained from sugar or starch in crops and other agricultural produce such as grain, sugarcane, sugar beets or even lactose. Since ethanol occurs in nature whenever yeast happens to find a sugar solution such as overripe fruit, most organisms have evolved some tolerance to ethanol, whereas methanol is toxic. Other experiments involve butanol, which can also be produced by fermentation of plants. Support for ethanol comes from the fact that it is a biomass fuel, which addresses climate change and greenhouse gas emissions, though these benefits are now highly debated,[23][25][26][27] including the heated 2008 food vs fuel debate.

6) Biodiesel (Fatty acid methyl ester), is commercially available in most oilseed-producing states in the United States. As of 2005, it is somewhat more expensive than fossil diesel, though it is still commonly produced in relatively small quantities (in comparison to petroleum products and ethanol). Many farmers who raise oilseeds use a biodiesel blend in tractors and equipment as a matter of policy, to foster production of biodiesel and raise public awareness. It is

sometimes easier to find biodiesel in rural areas than in cities. Biodiesel has lower Energy Density than fossil diesel fuel, so biodiesel vehicles are not quite able to keep up with the fuel economy of a fossil fuelled diesel vehicle, if the diesel injection system is not reset for the new fuel. If the injection timing is changed to take account of the higher Cetane value of biodiesel, the difference in economy is negligible. Because biodiesel contains more oxygen than diesel or vegetable oil fuel, it produces the lowest emissions from diesel engines, and is lower in most emissions than gasoline engines.

7) ***Biogas***

Compressed Biogas may be used for Internal Combustion Engines after purification of the raw gas. The removal of H2O, H2S and particles can be seen as standard producing a gas which has the same quality as Compressed Natural Gas. The use of biogas is particularly interesting for climates where the waste heat of a biogas powered power plant cannot be used during the summer

8) CNG

High pressure compressed natural gas, mainly composed of methane, that is used to fuel normal combustion engines instead of gasoline. Combustion of methane produces the least amount of CO_2 of all fossil fuels. Gasoline cars can be retrofitted to CNG and become bifuel NGV Natural gas vehicles as the gasoline tank stays.

9) Hydrogen

A hydrogen car is an automobile which uses hydrogen as its primary source of power for locomotion. These cars generally use the hydrogen in one of two methods: combustion or fuel-cell conversion. In combustion, the hydrogen is "burned" in engines in fundamentally the same method as traditional gasoline cars. In fuel-cell conversion, the hydrogen is turned into electricity through fuel cells which then powers electric motors. With either method, the only byproduct from the spent hydrogen is water.

b) What laws & acts in india prescribe pollution control limits & measures? Discuss in short.

Q.4) a) Explain with the help of the construction & working of FID & NDIR analyser. What for & how these are used?

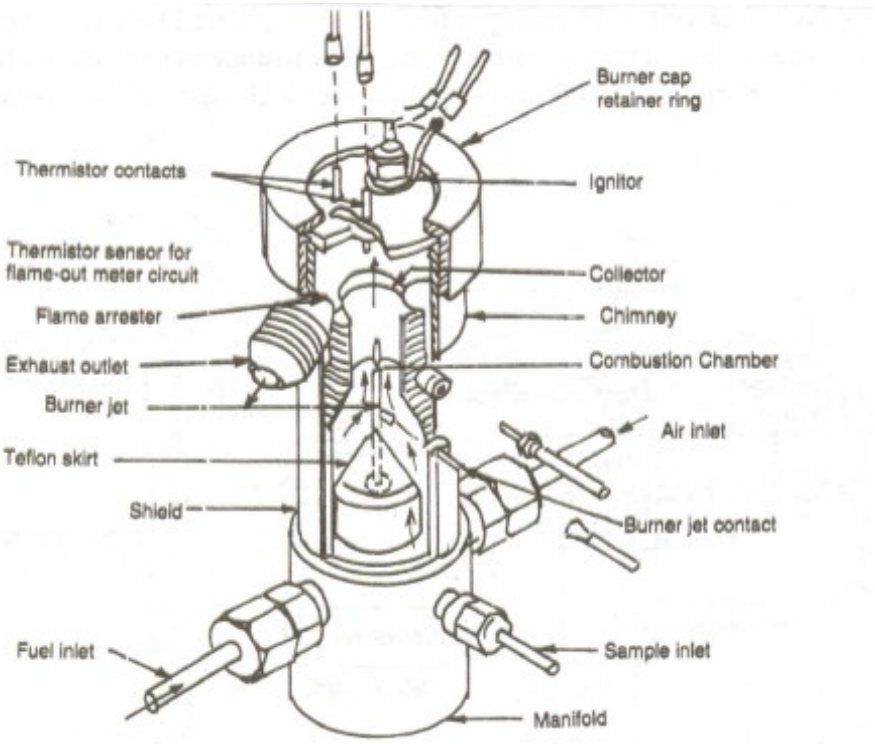
FID-

Flame lonisation Detector for Measuring He-emissions

When hydro-carbons are burned, electrons and positive ions are formed. If unburned hydrocarbons are burned in an electric field, then the current flow corresponds very closely to the number of Carbon atoms present. Flam lonisation detector is shown in Fig. The sample is mixed with the fuel and burn d in air. The fuel should not cause any ionisation so a hydrogen or hydrogen-helium mixture i us d. Th air should be of high purity for reducing the risk of introducing hydrocarbons. The fuel, nd ample flows ar to be regulated as the response of the

instrument is directly proportional to the flow rat of the sample as this influences the burner temp rature. The flows are regulated by maintaining fixed pressure difference across the device.

In Fig. 23.16, the burner jet-and annular collector form the electrodes and a potential of about 100 V is applied between them. The signals are amplified and calibration is acmeved by zeroing instrument with a sample containing pure N2.



NDIR-

Infra-red Absorption Gas Analyser for Measuring CO

The principle of this analyser is, infra-red radiation is absorbed by a wide range of gas molecules, each of which has a characteristic absorption spectrum. The fraction of radiation (t ,) at n particular wave length (A.) is given by Beer's Law as

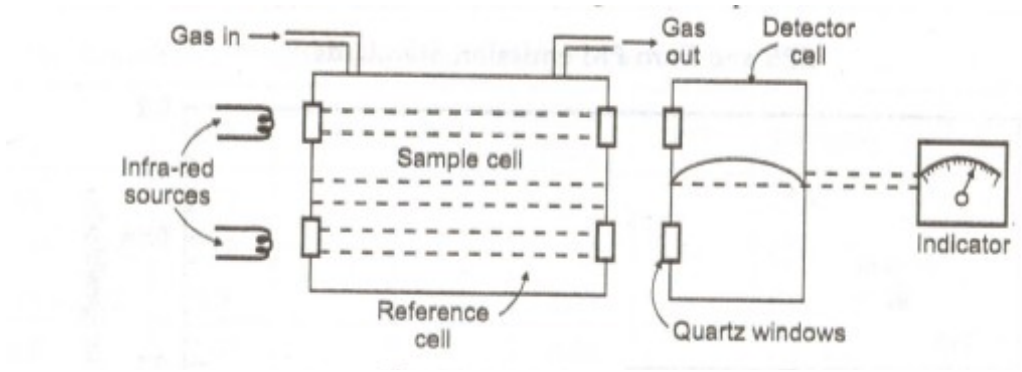
tl. =(cfpa",L

wher p is gas density and *Ct.1.* is the monochromatic absorptivity and L is the path length.

Fig. show the arrangement of this analy er. The detector cells are HIJed with the gas that i to be mea ured (CO or CO2), 0 that th y ab orb th radiation in th wave I ngth band associat·d with that gas. The energy absorbed in the detector cells causes the cell pressur to ri e. Th referenc cell is filled with air and the gas to be analysed flows through the sample cell. If the gas (CO) i pres nt in the sample then infra-red will be ab orbed in the sample cell and less infra-red will be nb orbed in th detector c II. This leads to a differential pressure in the detector cells which can be measured and related to the gas (CO) concentration. The calibration is carried out by passing gases of known composition through the sample cell.

Fig. 23.15 how the absorption spectra of CO and CO2, This shows that, infra-red radiation is ab orb d by both in the region of 4.4~. This means that when CO2 is present in the sample, it will affect the reading of CO and vice versa. Tms problem is eliminated by using a filter cell between

the infra-red sources and the sample and reference cells. If CO is to be measured, then the filter cell is filled with CO2 and any CO2 in the sample should not lead to any infra-red absorption. The windows of the analyser should be made of such materials (mica or quartz) which are transparent to infra-red radiation.



b) What do you mean by constant volume samplers?

The CVS-R03 is a complete constant volume sampling system that allows operators to dilute and sample exhaust gases generated by diesel or spark ignition engines under controlled conditions. The concept of CVS systems is long established and well regulated through standards and guidelines. The exhaust gas is diluted with dry filtered air (HEPA filters) to reduce its temperature and to avoid, at the same time, water condensation. A pump generates and maintains a constant diluted gas flow rate; this method allows operators to optimize the dilution factor in order to better control the temperature and the pollutant gases concentration and makes the system applicable for a wide range of engine types and sizes. The system can be supplied with up to 4 sampling bags for the dilution air and another 4 for the diluted gas. The CVS-R03 automatically performs a self-cleaning procedure before sampling in order to avoid contamination of the sampled gases; at the end of the test both the diluted gas and the dilution air can be sent to a gas analyzer.

All these key standard operations are performed by means of the user friendly software that also allows operators to collect and store all important operational data (temperatures, pressures, flows, volumes, etc) which allows for post processing savings on easy to manage ASCII files. CVS-R03 is fully compliant to European and American regulations so it can be used both for development and homologation. A complete remote control is available by means of RS232 or TCP/IP line using standardised AK protocols.

Q.5) a) Explain the working of Orsat Apparatus.

Orsat Apparatus

An **Orsat gas analyzer** is a piece of laboratory equipment used to analyse a gas sample (typically fossil fuel flue gas) for its oxygen, carbon monoxide and carbon dioxide content. Although largely replaced by instrumental techniques, the Orsat remains a reliable method of measurement and is relatively simple to use.

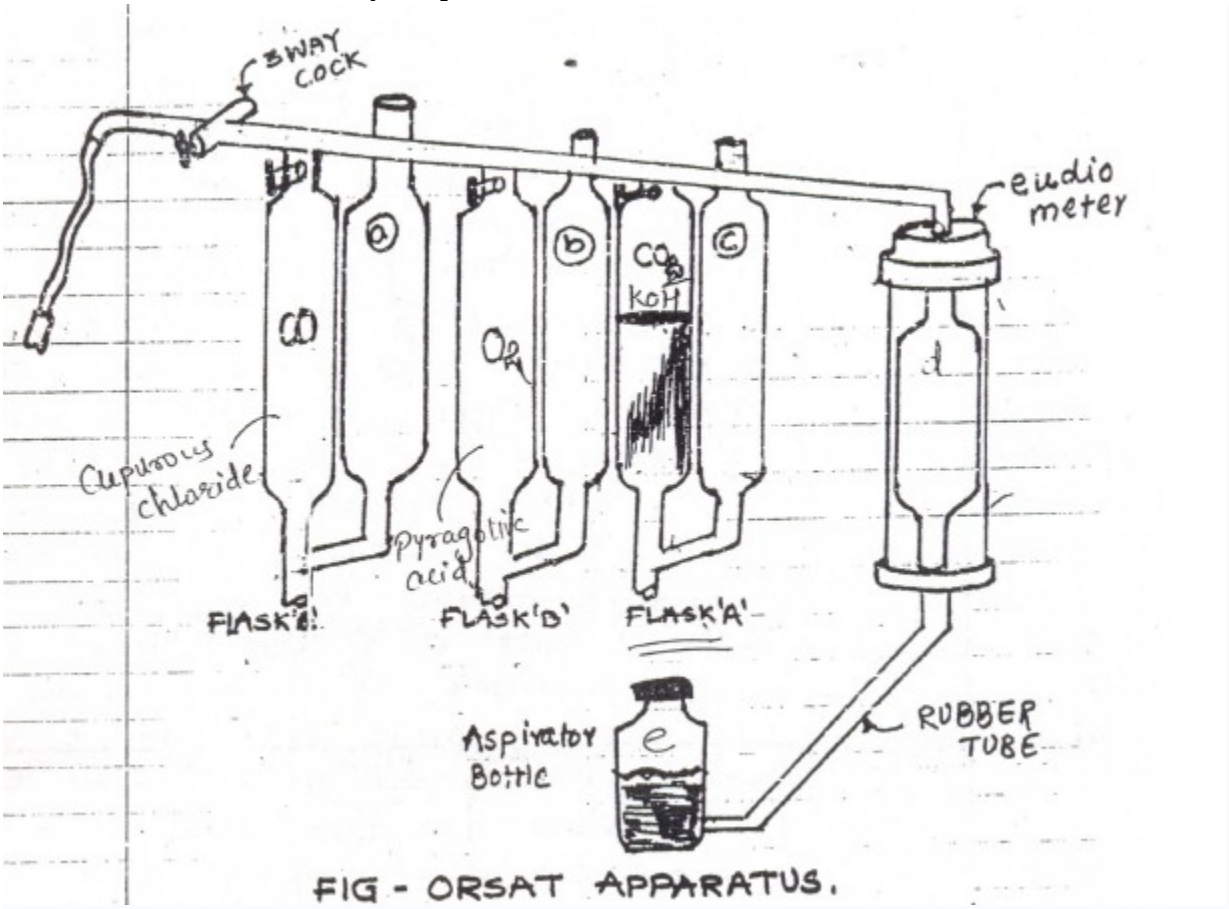


FIG - ORSAT APPARATUS.

The apparatus consists essentially of a calibrated water-jacketed gas burette connected by glass capillary tubing to two or three absorption pipettes containing chemical solutions that absorb the gasses it is required to measure. For safety and portability, the apparatus is usually encased in a wooden box.

The absorbents are:

Potassium Hydroxide (Caustic Potash)

Alkaline pyrogallol

ammoniacal Cuprous chloride

The base of the gas burette is connected to a levelling bottle to enable readings to be taken at constant pressure and to transfer the gas to and from the absorption media. The burette contains slightly acidulated water with a trace of chemical indicator (typically methyl orange) for colouration.

By means of a rubber tubing arrangement, the gas to be analysed is drawn into the burette and flushed through several times. Typically, 100mls is withdrawn for ease of

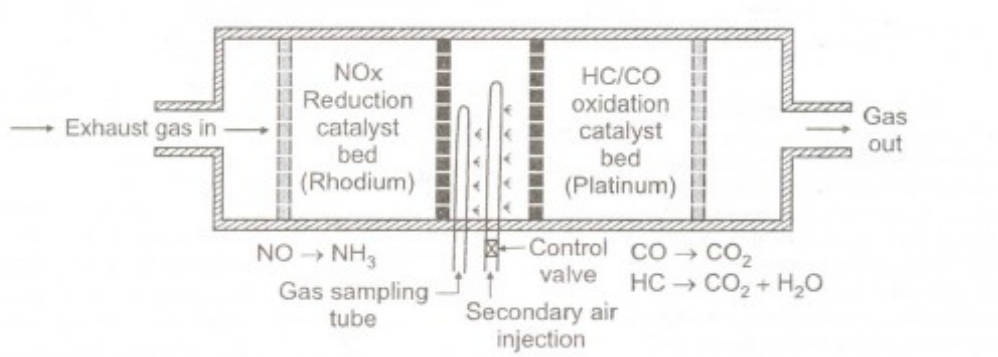
calculation. Using the stopcocks that isolate the absorption burettes, the level of gas in the levelling bottle and the burette is adjusted to the zero point of the burette.
The gas is then passed into the caustic potash burette, left to stand for about two minutes and then withdrawn, isolating the remaining gas via the stopcock arrangements. The process is repeated to ensure full absorption. After leveling the liquid in the bottle and burette, the remaining volume of gas in the burette indicates the percentage of carbon dioxide aborbed.
The same technique is repeated for oxygen, using the pyrogallol, and carbon monoxide using the ammoniac cuprous chloride.

b) Write short note on Globle warming & Green house effect.

Global warming is the increase in the average temperature of Earth's near-surface air and oceans since the mid-20th century and its projected continuation. Global surface temperature increased 0.74 ± 0.18 °C (1.33 ± 0.32 °F) between the start and the end of the 20th century.[2][A] The Intergovernmental Panel on Climate Change (IPCC) concludes that most of the observed temperature increase since the middle of the 20th century was very likely caused by increasing concentrations of greenhouse gases resulting from human activity such as fossil fuel burning and deforestation.[2] The IPCC also concludes that variations in natural phenomena such as solar radiation and volcanic eruptions had a small cooling effect after 1950. These basic conclusions have been endorsed by more than 40 scientific societies and academies of science, including all of the national academies of science of the major industrialized countries.
The greenhouse effect is the process by which absorption and emission of infrared radiation by gases in the atmosphere warm a planet's lower atmosphere and surface. It was discovered by Joseph Fourier in 1824 and was first investigated quantitatively by Svante Arrhenius in 1896.[28] Existence of the greenhouse effect as such is not disputed, even by those who do not agree that the recent temperature increase is attributable to human activity. The question is instead how the strength of the greenhouse effect changes when human activity increases the concentrations of greenhouse gases in the atmosphere.

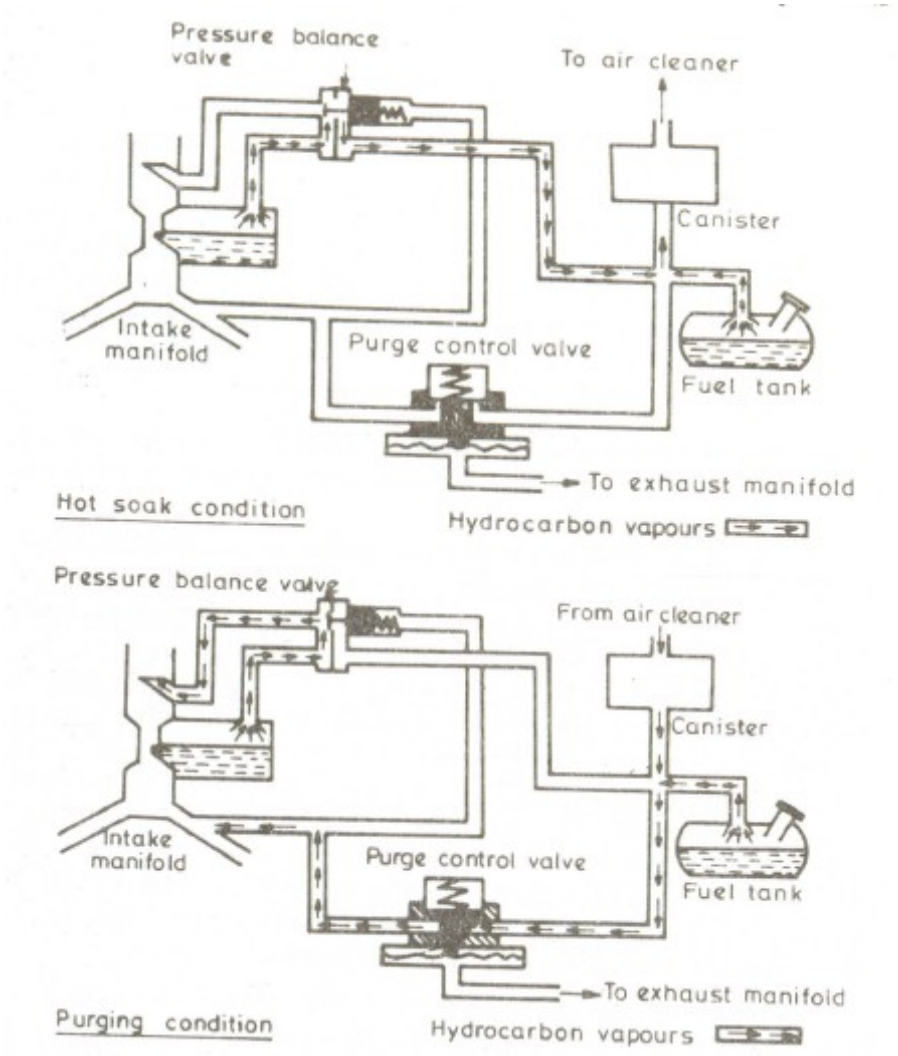
Q.6) a) Explain the mechanism of diesel smoke formation & its control.
b) Explain with block diagram, electronic engine management for emission control.

Q.7) Write a short on-
a) Catalytic converter-



Catalytic Converters. Catalytic oxidation of the exhausted HC and CO is accomplished by placing i"lcommon device called catalytic converter in the vehicle exhaust system. The catalytic converter is filled with catalytic material. Exhaust gas hydrocOilrbons and CO are oxidised while passing through the bed. The catalytIc material itself does not enter into the reaction but only promotes the oxidation process at lower temperature. Usually air compressor is used to supply i"ldditional oxygen necessary for complete oxidation of the exhaust gas stream. A catalyst is an agent that aids or speeds a process or chemical reactIOn without becoming a pi"lrt of rCi1ction during the process - sort of a chemical middleman. In a modern car's emIssions control system, the so-called 3-way catalyst helps the three major evil elements of exhaust, - h}droci1rbons (HC), carbon monoxide (CO) and oxides of nitrogen *(NOx)* - react with oxygen and eJch other. The catalyst helps the HC and CO become non-poisonous carbon dioxide (C02) i1nd wi"lter vi1por, while the 1 *OX* IS converted into CO2, nitrogen and water vapor.

b) Evaporative emission & there control-



The purpose of this device is to collect all evaporative emissions (vapours) and reCIrculating them at a proper time. The device is shown in Fig. 23.43. It consists of an absorbent chamber, pressure balancing valve and purge control valve. The absorbent chamber contains charcoal which can hold the hyd rocarbon vapour before escaping to atmosphere. The fuel tank and carburettor float, which are main sources of HC emission in form of vapour are directly connected to absorbent chamber when the engine is turned off *i.e.* under hot soak-condition. This causes the petrol to boil from carburettor float and large amount of petrol vapour comes out. All these vapours are during stopping or running the engine are absorbed in the absorber chamber.

When the absorber bed becomes saturated, the air coming out from air-cleaner is passed through absorber bed and the air-with-vapour are passed to inlet manifold through the purge valve. At this time, the seat of the pressure balancing valve is so located that there is direct pressure communication between the internal vent and top of the carburettor float mamtaining the

desIgned carburettor metenng forces. The operation of the purge control valve is controlled by the exhaust back pressure as shown in figure. The fuel supply is cut-off under idling condition and level of HC is reduced.

c) Recent development in automotive industry for pollution control measures

Alternative fuel vehicles are another option that is less polluting than conventional petroleum powered vehicles.

Fully autonomous vehicles, also known as robotic cars, or driverless cars, already exist in prototype, and are expected to be commercially available around 2020. According to urban designer and futurist Michael E. Arth, driverless electric vehicles—in conjunction with the increased use of virtual reality for work, travel, and pleasure—could reduce the world's 800,000,000 vehicles to a fraction of that number within a few decades.[33] This would be possible if almost all private cars requiring drivers, which are not in use and parked 90% of the time, would be traded for public self-driving taxis that would be in near constant use. This would also allow for getting the appropriate vehicle for the particular need—a bus could come for a group of people, a limousine could come for a special night out, and a Segway could come for a short trip down the street for one person. Children could be chauffeured in supervised safety, DUIs would no longer exist, and 41,000 lives could be saved each year in the U.S. alone.

Automobile propulsion technology under development include gasoline/electric and plug-in hybrids, battery electric vehicles, hydrogen cars, biofuels, and various alternative fuels.

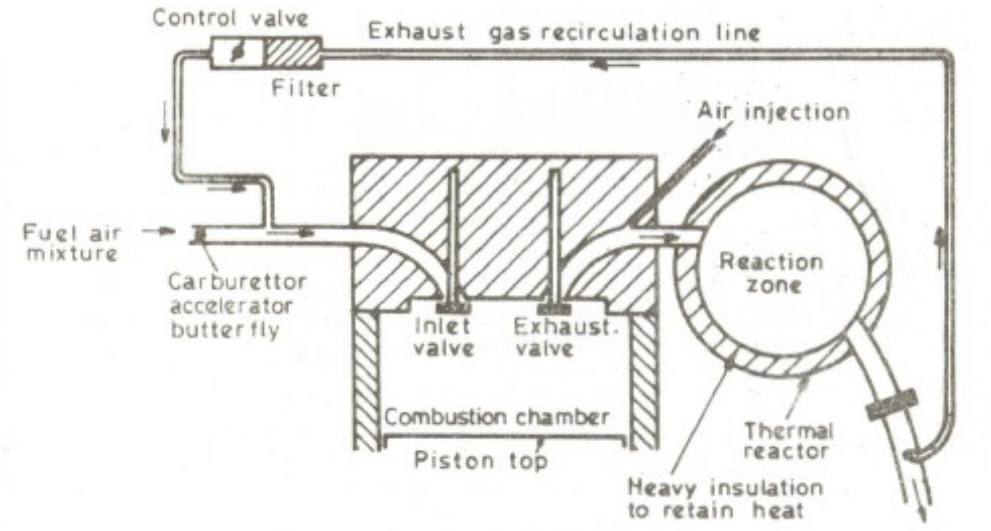
Research into future alternative forms of power include the development of fuel cells, Homogeneous Charge Compression Ignition (HCCI), stirling engines,[36] and even using the stored energy of compressed air or liquid nitrogen.

New materials which may replace steel car bodies include duraluminum, fiberglass, carbon fiber, and carbon nanotubes.

Telematics technology is allowing more and more people to share cars, on a pay-as-you-go basis, through such schemes as City Car Club in the UK, Mobility in mainland Europe, and Zipcar in the US.

Established alternatives for some aspects of automobile use include public transit (buses, trolleybuses, trains, subways, monorails, tramways), cycling, walking, rollerblading, skateboarding, horseback riding and using a velomobile. Car-share arrangements and carpooling are also increasingly popular–the U.S. market leader in car-sharing has experienced double-digit growth in revenue and membership growth between 2006 and 2007, offering a service that enables urban residents to "share" a vehicle rather than own a car in already congested neighborhoods.[40] Bike-share systems have been tried in some European cities, including Copenhagen and Amsterdam. Similar programs have been experimented with in a number of U.S. Cities.[41] Additional individual modes of transport, such as personal rapid transit could serve as an alternative to automobiles if they prove to be socially accepted

d) Emission control by EGR-



In Fi~. 20.20 is shown sch~mati~ly the exhaust gas recirculation system. A portion of the exhaust gas IS reclC~ulated to the cylinder intake charge. This reduces the peak combustion temperature, since the inert gas serves as a heat sink. This also reduc- es the quantity of oxygen available for combustion.

The exhaust gas for recirculation is directly taken from the stove a~ea through an orific, passed through the butterfly control valve for regulation of the rate and ducted down to the intake port. The recycle rate control valve is connected to the throttle shaft by'means of appropriate linkage and the amount of valve opening is regulated by throttle position. The link is designed so that recycled exhaust is normally shut off during idle to prev~nt rough engine operation. This is also shut off durt~H ~hrottle acceleratl~n to prevent loss of power when maximum performance IS needed: There will be a little effect on *NOx* emission even if the above C1!.!angementIS not made because *NOx* concentration is idle and full throttle are already very low.