V SEMESTER B.TECH. (AUTOMOBILE ENGINEERING)

END SEMESTER EXAMINATIONS, DECEMBER 2020

SUBJECT: AUTOMOTIVE POLLUTION AND CONTROL [AAE4301]

REVISED CREDIT SYSTEM (SCHEME)

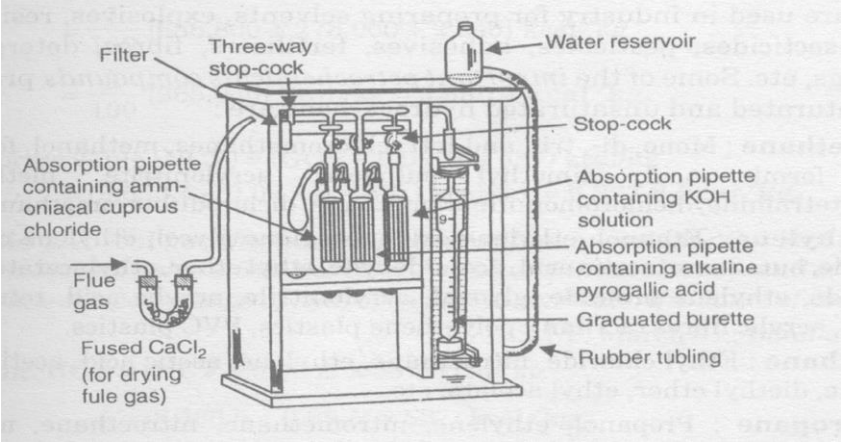
(08/01/2021)

Duration: 3 Hours Max. Marks: 50

Instructions to Candidates:

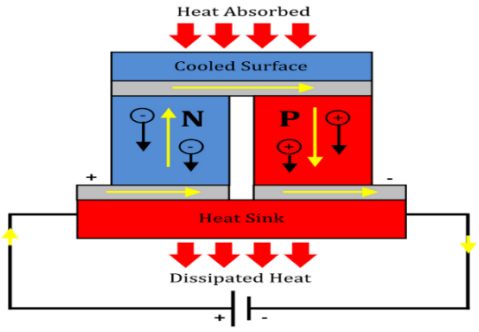
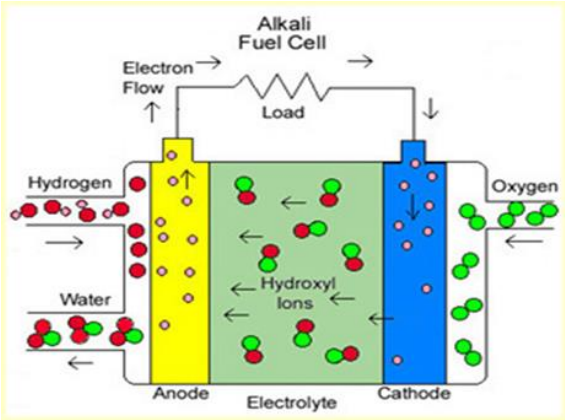
- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Draw sketches in **PENCIL** only

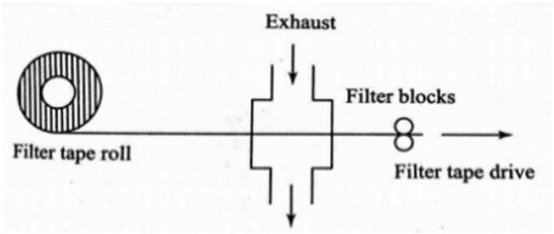
1A)	What are the cause and effects of Hydrocarbon and Carbon monoxide pollutants on human being The incomplete burning of the air-fuel mixture in the combustion chamber produces pollutants. **Hydrocarbon:** **Cause:** The UBHC emission is the direct result of incomplete combustion. The emission amount of HC is closely related to • Design variables - Combustion chamber design • Operating variables such as A:F ratio, speed, load and mode of operation as idling, running or accelerating. Surface to volume ratio and wall quenching greatly affects in formation of HC. Hydrocarbons, derived from unburnt fuel emitted by • Exhausts • Engine crankcase fumes • Vapour escaping from the carburettor are also harmful to health. Unburned or partially burned hydrocarbons in gaseous form combine with oxides of nitrogen in the presence of sunlight to form photochemical smog. UBHC + NOx ⟶ Photochemical smog **Effect:** The products of photochemical smog cause watering and burning of the eyes and affect the respiratory system, especially when the respiratory system is marginal for other reasons. **Carbon monoxide**: **Cause:** CO is intermediate product of combustion remains in exhaust if the oxidation of CO to CO_2 is not complete. Theoretically , it can be said that petrol engine exhaust is free of CO if the air fuel ratio is 15. However, some CO is always present in the exhaust even at lean mixture and can be as high as 1%. CO is generally formed when the mixture is rich in fuel. This is due to the fact that equilibrium is not established when the products pass to the exhaust. **Effect:** It is a colour less gas of about the same density as air. It is a poisonous gas which, when inhaled, replaces the oxygen in the blood stream so that the body's metabolism cannot function correctly. Small amounts of CO concentrations, when breathed in, slow down physical and mental activity and produces headaches, while large concentration will kill.	**(03)**
1B)	What is the necessity for pollutant measuring instruments? Explain with neat sketch constructional & operational details of ORSAT equipment. The emission regulations specify the type, principle of operation used and generic construction of the exhaust gas analyzers which can be employed for emission certification of vehicles and engines. To have proper control	**(05)**

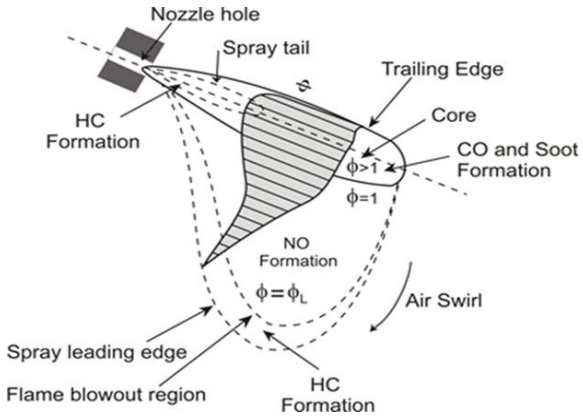
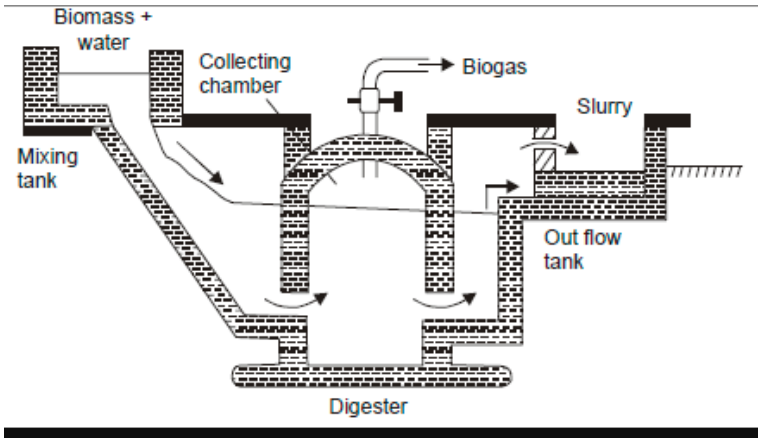
	on combustion process, an idea about complete or complete combustion of fuel is made by the analysis of flue gas. Thus, • if the gases contain considerable amount of carbon monoxide, it indicates that incomplete combustion is occurring (i.e. considerable wastage of fuel is taking flue). Also indicates the short supply of oxygen for combustion • if the flue gases contain a considerable amount of oxygen, it indicates the oxygen supply is in excess, though the combustion may be complete.  **CONSTRUCTION:** Consists of a water-jacketed measuring burette, connected in series to a set of three absorption bulbs, each through a stopcock. The other end is provided with a three-way stop-cock, the free end of which is further connected to a U-tube packed with glass wool (for avoiding the incoming of any smoke particles, etc.). The graduated burette is surrounded by a water-jacket to keep the temperature of the gas constant during the experiment. The lower end of the burette is connected to a water reservoir by means of a long rubber tubing. **FUNCTIONAL:** The absorption bulbs are usually filled with glass tubes, so that the surface area of contact between the gas and the solution is increased. The absorption bulbs have solutions for the absorption of CO_2, O_2 and CO respectively. • ***First bulb*** has *'**potassium hydroxide'** solution* (250g KOH in 500mL of boiled distilled water), and ***it absorbs only CO_2.*** • ***Second bulb*** has a solution of ***'alkaline pyrogallic acid'*** (25g pyrogallic acid+200g KOH in 500 mL of distilled water) and ***it can absorb CO_2 and O_2.*** • ***Third bulb*** contains ***'ammonical cuprous chloride'*** (100g cuprous chloride + 125 mL liquor ammonia+375 mL of water) and ***it can absorb CO_2 ,O_2 and CO.*** Hence, it is necessary that the flue gas is passed first through potassium hydroxide bulb, where CO_2 is absorbed, then through alkaline pyrogallic acid bulb, when only O_2 will be absorbed (because CO_2 has already been removed) and finally through ammonical cuprous chloride bulb, where only CO will be absorbed.	
1C)	Explain with features effective utilization of biodiesel as biofuel in engine. In which engine do you recommend this fuel? Biodiesel is a kind of fuel produced by a process known as Transesterification. This is a process of transformation of one type of ester into another type of ester. Vegetable oil is a triglyceride. Glycerine is separated from oil ester	**(02)**

	and alcohol is added and formed as alcohol ester known as bio diesel. Biodiesel is defined as the monoalkyl esters of vegetable oils or animal fats. It is the best substitute for diesel fuels in diesel engines. The biggest **advantage** that biodiesel over gasoline and petroleum diesel is its environmental friendliness. The higher heating values of biodiesels are closer to that of the petroleum products in the range of 39–41 MJ/kg which is slightly lower than that of gasoline (46 MJ/kg), petro diesel (43 MJ/kg) or crude petroleum (42 MJ/kg), but higher than coal (32–37 MJ/kg). Important operating disadvantages of biodiesel in comparison with petro diesel are cold start problems, the lower energy content, higher copper strip corrosion and fuel pumping difficulty from higher viscosity. This increases fuel consumption when biodiesel is used in comparison with application of pure petro diesel, in proportion to the share of the biodiesel content. Taking into account the higher production value of biodiesel as compared to the petro diesel, this increase in fuel consumption raises in addition to the overall cost of application of biodiesel as an alternative to petro diesel. This oil is recommended in Diesel Engine.	
2A)	What is the need for stratified charge system in modern engine? What are the advantages of this system? The stratified-charge engine is something of a hybrid between the homogeneous-charge spark ignition engine and the diesel engine. The concept is aimed at incorporating some of the design features of each engine in order to achieve some advantages of both. The result has been an engine more nearly like the spark-ignition engine, but one in which much leaner operation can be achieved and which is able to burn a wide variety of fuels. Since most of the times engine runs at part load and max power output conditions, these obstacles need to overcome. This is attempted by charge stratification-- it is an engine midway between homogenous charge SI and heterogeneous charge CI engines. Charge stratification means providing different F/A mixtures at various places in the combustion chamber- a relatively rich mixture near the spark plug and a leaner mixture in the rest of the combustion chamber. Whole F/A mixture is distributed in layers or strata of different mixture strengths across the combustion chamber while the overall mixture is rather lean. **Potential Advantages of DISC Engines;** • The mixture being rich near spark plug good ignition characteristics without misfire obtained. • High combustion temperatures obtained as a result of initial burning of rich mixtures near spark plug produce high flame speeds that burn the lean mixtures in the cylinder away from spark plug. • The overall air-fuel ratio can be very lean reaching 40:1 to 50:1 giving high fuel efficiency. • An unthrottled engine operation is possible such that the engine power may be controlled by varying only the fuel flow. It would reduce pumping losses. • The end gases being very fuel lean, precombustion reactions would be very slow leading to reduced knocking tendency. Hence, a higher compression ratio can be used further improving the fuel efficiency. • Presence of rich mixture near spark plug keeps the formation of NOx at low levels. The mixture that burns early is deficient in oxygen although it attains high combustion temperatures. • Overall mixture being lean very low CO produced as the CO produced early in combustion can be oxidized within the cylinder itself by the excess oxygen available. • The mixture in piston ring crevice region being very lean the contribution of crevices to HC emissions would also be very low. • The direct injection of fuel in the cylinder can decrease HC emissions during warm-up after cold start, as liquid fuel film is not formed in the intake manifold and port. In addition, a smaller fuel quantity needs to be injected during cold start compared to PFI engines.	**(03)**

	• With direct injection of gasoline a faster dynamic response is possible hence a flatter air-fuel ratio curve during acceleration can be used that provides lower HC emissions. • The DISC engines can tolerate higher EGR rates than the homogeneous charge SI engines and hence larger reductions in NOx	
2B)	What are the effects of following operating variables on the formation of hydro carbons of in CI engine: (i) surface temperature (ii) surface to volume ratio **HC emission**: Combustion chamber ***surface temperature*** affects the unburned HC emissions by changing the thickness of combustion chamber quench layer and degree of after burning. Higher the combustion chamber surface temperature, the lower are the HC emissions. In addition to changing quench distance and after-reaction, changing engine temperature increases fuel evaporation and distribution, and result in a faster reaction and hence reduced HC emission. **HC emission**: Because HC emissions arise primarily from quenching at the combustion chamber wall surface, it is desirable to minimize the surface area of the chamber. The ratio of ***surface area to volume*** of the combustion chamber (S / V) is useful for interpreting the effects of many designs and operating variables on HC concentration. Lowering the S/V ratio reduces HC emission concentration.	**(03)**
2C)	Explain how white, black and blue smoke formation takes place. List the factors which contributes in the formation of smoke. Engine exhaust smoke is a visible indicator of the combustion process in the engine. It is due to incomplete combustion. Smoke in diesel engine can be divided into three categories: blue, white and black. **Blue smoke**: It results from the burning of engine lubricating oil that reaches combustion chamber due to worn piston rings, cylinder liners and valve guides. **White or cold smoke:** It is due to unburnt or partially burnt fuel droplets and is usually associated with the engine running at: • less than normal operating temperature after starting, • long period of idling, • operating under very light load, • operating with leaking injectors • water leakage in combustion chamber. This smoke normally fades away as engine is warmed up and brought to normal stage. **Black or hot smoke**: It consists of unburnt carbon particles (0.5 – 1 microns in diameter) and other solid products of combustion. This smoke appears after engine is warmed up and is accelerating or pulling under load. The smoke intensity in the diesel exhaust is generally affected by many parameters. They are: • Injection timing, Rate of Injection • Injection nozzle • Maintenance • Fuel, Engine type and speed • Fuel air ratio • Load	**(04)**
3A)	Explain with neat sketch phenomenon of Peltier effect.	**(03)**

	Peltier effect: Whenever current passes through the circuit of two dissimilar conductors, depending on the current direction, either heat is absorbed or released at the junction of the two conductors. This is known as Peltier effect.  Peltier effect is the opposite of the Seebeck Effect. The electrical current could be used to create a temperature differential in two dissimilar metals. Depending on which way the current flows in the circuit, the places where the two metals are joined together can be made either hot or cold. Applied voltage to the metals is proportional to the temperature differential created. The proportionality constant in this case is called the Peltier Coefficient.	
3B)	Explain with neat sketch operational and constructional details of Alkaline fuel cells. Write its advantages and disadvantages.  The alkaline fuel cell or hydrogen-oxygen fuel cell consists of two porous carbon electrodes impregnated with a suitable catalyst such as Pt, Ag, etc. The space between the two electrodes is filled with a concentrated solution of KOH or NaOH which serves as an electrolyte. ***H_2*** gas and ***O_2*** gas are bubbled into the electrolyte through the porous carbon electrodes. Thus, the overall reaction involves the combination of hydrogen gas and oxygen gas to form water. The cell runs continuously until the ***reactant's supply is exhausted***. This type of cell ***operates efficiently*** in the temperature range ***343 K to 413 K*** and provides a potential of about ***0.9 V.*** The fuel cell produces power through a redox reaction between hydrogen and oxygen. ***At the anode***, hydrogen is oxidized according to the reaction: $2H_2 + 4OH^- \longrightarrow 4H_2O + 4e^-$ producing water and releasing electrons. The electrons flow through an external circuit and return to the cathode, reducing oxygen in the reaction: $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$ producing hydroxide ions. The net reaction consumes one oxygen molecule and two hydrogen molecules in the production of two water molecules. Electricity and heat are formed as by-products of this reaction.	**(05)**
3C)	Explain with a valid reason, the effect of varying compression ratio and blending of bio ethanol on the formation of hydrocarbon pollutant. Increasing compression ratio reduces fuel consumption; this is due to reduction in cylinder volume, which reduce mass of charge intake. Presence of oxygen in ethanol composition allow better combustion product, complete combustion result in high temperature and pressure inside cylinder thus higher output power.	**(02)**

	The fuels containing high ratios of ethanol has important effects on the reduction HC emissions. The HC emission effectively reduced with ethanol edition. The maximum reduction of HC emission at (10:1) higher compression ratio with pure ethanol.	
4A)	What is wall quenching? How and where does it happens? What is the effect of this phenomenon on the formation of pollutant? The cooling of flame near the combustion chamber walls is known as ***wall quenching***. This is a combustion phenomenon which arises when the flame tries to propagate in the vicinity of a wall. Normally the effect of the wall is a slowing down or stopping of the reaction. Because of the cooling, there is a cold zone next to the cooled combustion chamber walls. This region is called the quench zone. Due to low temperature, the fuel-air mixture fails to burn and remains unburned. Due to this, exhaust gas shows a marked variation in HC emission. • The first gas that exits is from near the valve and is relatively cool due to which it is rich in HC. • The next part of gas that comes is from the hot combustion chamber and hence a low HC concentration. • The last part of the gas that exits is scrapped off the cool cylinder wall and is relatively cool. Therefore it is also rich in HC emission	**(04)**
4B)	Explain with neat sketch operational details of continuous filter type smoke meter.  **Continuous filter type smoke meter**: Measurement of smoke intensity is achieved by continuously passing exhaust gas through a moving strip of filter paper and collecting particles. Ex. Van Brand Smoke meter.	**(03)**
4C)	Explain the operational details and important features of three-way catalytic converter system. What are the advantages of this system? Out of many technologies available for automobile exhaust emission control a catalytic converter found to the best option to control HC, CO and NOx emissions from petrol driven vehicles while diesel particulate filter and diesel oxidation catalyst or oxidation catalysts converter have so far been the most potential option to control particulates emissions from diesel driven vehicle. A catalytic converter placed inside the tailpipe through which deadly exhaust gases containing HC, CO, NOx emitted. The function of the catalytic convertor is to convert these gases into CO2, H2O, N2 and O2 and currently, it is necessary for all automobiles pursuing on road. Catalytic Converter is the emission control device, to convert the toxic by- products of combustion in the exhaust of an internal combustion engine to less toxic product by using catalyst chemical reactions. The role of a catalyst in decrease of pollutants with exhaust impurities is pertinent by the electric control Device (ECD) of the car power train.	**(03)**

	Mostly the performance of catalyst converter is highly reliant on the type of catalyst used in an assembly. The rate of the chemical reactions is affected by the presence of catalyst. Catalyst acts as a mediator that reduces the activation energy of the reaction of interest, commonly not being transformed during the reactive chain.	
5A)	Explain with a neat sketch cause and effects of over mixing phenomenon in diesel engine.  Overmixed region in a diesel spray injected in swirling air is explained in **Fig.** The ***overmixing*** of fuel in the ***LFOR region*** near the ***spray boundary*** may result due to ***high air swirl and/or longer time available*** before ***combustion starts*** (longer ignition delay). ***Overmixing*** results in ***over-leaning*** of the mixture beyond the ***lean flammability*** limit and it will not ***auto-ignite or support combustion***	**(03)**
5B)	Explain with neat sketch operational details of Fixed dome type of Biogas Plant.  Fixed dome type of Biogas Plant Raw materials required: Forms of biomass listed below may be used along with water. • Animal dung , Poultry wastes • Plant wastes (Husk, grass, weeds etc.) • Human excreta • Industrial wastes(Saw dust, wastes from food processing industries) • Domestic wastes (Vegetable peels, waste food materials) The biogas plant is a brick and cement structure having the following five sections: Mixing tank present above the ground level. Inlet tank: The mixing tank opens underground into a sloping inlet chamber. Digester: The inlet chamber opens from below into the digester which is a huge tank with a dome like ceiling. The ceiling of the digester has an outlet with a valve for the supply of biogas. Outlet tank: The digester opens from below into an outlet chamber. Overflow tank: The outlet chamber opens from the top into a small over flow tank.	**(05)**

5C)	What are the important factors of bioethanol recommend as blending fuel in SI engine? Why it is not recommended in CI engine? Presence of oxygen in ethanol composition allow better combustion product, complete combustion result in high temperature and pressure inside cylinder thus higher output power. Increased pressure and temperature inside cylinder, which results in higher power output. Oxygenated additive (E) enhance proper combustion inside cylinder, which increase exhaust gas temperature. Therefore, proper cooling for engine is required when engine is running with ethanol blends. Ethanol has high anti-knock quality due to its high ***octane number***, ***high combustion speed*** and ***high latent heat*** of evaporation, which decreases the compressed gas temperature during the compression stroke.	**(02)**