Important Instructions to examiners:
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

	Marks
1. A) Attempt any three of the following :	**12**
a) What is ignition lag? State the factors effecting the same (four points)	04
Answer: Ignition lag: The time elapsed between the fuel injection into the combustion chamber and starting of combustion. It is a chemical process in which the growth and development of a self propagating nucleus of flame is produced. OR It is the time immediately following injection of the fuel during which the ignition process is being initiated and the pressure does not rise beyond the value it would have due to compression of air. **Factor affecting the ignition lag:** *(Any four points – 02 marks)* 1) Self-Ignition Temperature of the fuel 2) Injection timing 3) Compression ratio 4) Engine speed 5) Air fuel ratio 6) Initial Temperature and pressure. 7) Presence of residual gases. 8) Engine size	02 02
b) List four drawbacks of carburetor S.I. engine.	04
Answer: Drawbacks of carburetted S.I. engine: *(Any Four points- 04 marks)* 1) Mal-distribution of charge. 2) Variation in air: fuel ratio. 3) Inaccurate metering of charge. 4) Does not meet emission norms. 5) No temperature compensation. 6) No compensation of Exhaust gas recirculation. 7) Fuel atomization depends upon velocity of air in the venture. 8) Wear and tear of parts results in poor efficiency. 9) Backfiring may take place. 10) Carburettor Icing may take place.	04

c) State four features of CRDI system.	04
Answer: Features of CRDI system: *(Four points -04 marks)* 1) CRDI engine has lower emission. So, it meets latest emission norms. Finely atomized fuel results in an efficient air-fuel mixing & reduced particulate emissions. 2) It gives improved fuel economy. 3) CRDI engine has lower engine noise level. CRDI engines have capability to deliver stable, small pilot injections can be used for decreased NO_x emissions and noise. 4) All the cylinders have balanced engine cylinder pressures. (i.e. reduced torsional vibrations). 5) Separation of pressure generation and injection allowing flexibility in controlling both the injection rates and timing of CRDI. 6) In CRDI system, Common rail pressure does not depend on the engine speed and load conditions. 7) In CRDI, High injection pressures (about 1500 bar) and good spray preparations are possible even at low engine speeds and loads. 8) In CRDI system, Fuel pump operates with low drive torque. 9) High pressure accumulator (common rail) provides consistently high pressure fuel to injectors. 10) Use of high pressure pump which allows the fuel to be supply at higher pressure under all operating condition.	04
d) Describe four properties of diesel fuel.	04
Answer: Properties of diesel fuel: *(Any Four Properties – 04 marks)* 1) **Volatility**: - The fuel should be sufficiently volatile in the operating range of temperature to produce good mixing and combustion. 2) **Viscosity:** Viscosity of a fuel is a measure of its resistance to flow. 3) **Flash point:** Flash point is the temperature at which a flammable liquid will produce, with a standardized apparatus and procedure, a mixture of its vapour and air which will ignite to give a visible flash by contact with an open flame. 4) **Fire point:** Fire point is the temperature at which the flash will sustain itself as a steady flame for at least five seconds. 5) **Cetane number:** The Cetane rating of a diesel fuel is measure of its ability to auto-ignite quickly when it is injected into the compressed and heated air in the engine. 6) **Calorific value:** It is about 50 MJ/Kg 7) **Sulphur:** High sulphur content in diesel fuel causes corrosion, wear of engine parts, especially the cylinder walls, and tends to increase the rate of sticky and sludge - like deposits. 8) **Contamination:** The contents of sand and rust particles can clog small openings and abrasive particles can damage injector surface piston rings and cylinder walls. 9) **Cloud point:** The temperature below which the wax content of the petroleum oil separates out in the form of a solid is called cloud point. Such waxy solid can clog fuel lines and fuel filters. 10) **Pour point:** Pour point is the temperature below which the entire mass of fuel, solid or liquid together, freeze and thus cause flow of fuel impossible. Pour point is usually 5 to 10 °C below the cloud point.	04

B) Attempt any one of the following :	06
a) With the help of neat sketch explain the working of fuel injector used in MPFI system.	06

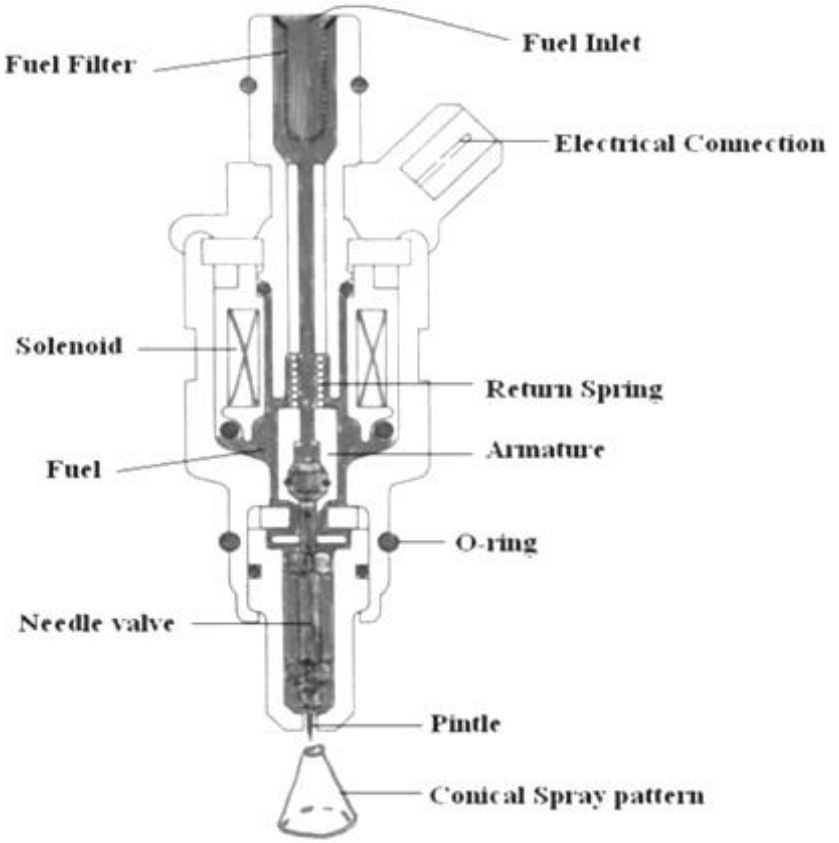
Answer: Working of fuel injector used in MPFI system:

In MPFI system, Top feed fuel Injector is used. These injectors are solenoid-operated valves that are opened and closed by means of electric pulses from the ECU. The injectors are mounted in the intake manifold and spray onto the back of the intake valves. In general, one injector is used for each cylinder.

The injected fuel mass is determined by the injector opening time (for a given pressure drop across the injector). In MPFI systems, each engine cylinder is assigned an electromagnetic fuel injector, which is activated individually for each cylinder. In this way, both the fuel mass appropriate to each cylinder and the correct start of injection are calculated by the control unit (ECU) 03

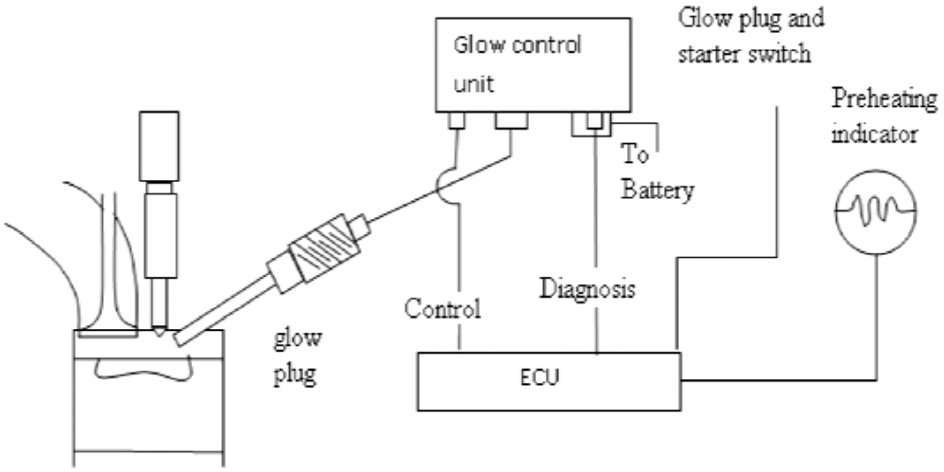
The amount of fuel sprayed from the injectors is controlled by cycling the injectors open and close. More fuel will be sprayed out when the injector pulse is longer. In order to operate properly, the fuel must spray as a liquid throughout the injection. Injection pressure is approximately 2 bar to 3.5 bar.

Pressure helps to keep the fuel as a liquid throughout the system. When the solenoid coil is energized, the Pintle is pulled up. System pressure then forces fuel between the Pintle and discharge opening to form a fine spray pattern that has a cone shape.



03

Figure: Top Feed Fuel Injector

b) Explain the operation of glow plug with the help of circuit diagram.	06
Answer: Operation of glow plug: Glow plug is an aid for cold starting of a C.I. engine. The self-ignition temperature of diesel is 250°C. For compression ignition, the charge (air + diesel) should reach a temperature of about 550°C. Cold weather conditions make it difficult to happen. So, a glow plug is used in Compression Ignition Engines. The glow plug heats to starting temperature (approx. 850°C) as rapidly as possible. **Operation of Glow Plug Circuit:** On modern vehicles, engine's central ECU controls- high electrical glow-plug current, indicator lamp, Safety override and automatic switching off the Glow- plugs. An ignition starter lock controls the current supply for the glow system. As the switch is actuated a relay connects the glow plug to the battery circuit, and the Indicator lamp comes on. When the lamp goes out turning the switch further to the starting position brings the engine to life. As long as the starter switch is held in the glow position, a holding circuit assures that the glow- plugs remain on. Then after starting, when the ignition switch is released, they are automatically switched off. A safety circuit prevents running the battery down if the engine fails to start immediately. After a maximum of 90 seconds glow time, current to the glow plugs is automatically interrupted. But starting may be attempted again as soon as the driver wishes.  Fig: ECU controlled Glow plug System on D.I. Engine	03 03
2. Attempt any four of the following :	16
a) Define pre-ignition and surface ignition.	04
Answer: **Definition:** **Pre-ignition:** Pre-ignition is the ignition of the homogeneous mixture in the cylinder, before the timed ignition spark occurs, caused by the local overheating of the combustible mixture. Pre ignition is initiated by some overheated projecting part such as the sparking plug electrodes, exhaust valve head, metal corners in the combustion chamber, carbon deposits etc. **2. Surface ignition:** Surface ignition is the ignition of the fuel-air mixture by a hot spot on the combustion chamber walls such as on overheated valve or spark plug or glowing combustion chamber i.e. any means other than the normal spark discharge. Due to surface ignition a turbulent flame develop at each surface ignition locations and start propagates across the chamber in an analogous manner to what occurs in normal knock.	02 02

b) State function and location of 04
i) Oxygen sensor ii) Engine temperature sensor
iii) Air flow sensor iv) Throttle position sensor

Answer :

i) Oxygen sensor:
Function: It is used to monitor the amount of oxygen in the exhaust gas 01
Location: It is located in exhaust system, near to exhaust valve

ii) Engine temperature sensor:
Function: Measures the temperature of the coolant in the system and sends signal to ECU. 01
Location: It is located at engine block or coolant passage

iii) Air flow sensor:
Function: It is used to tell the ECU the mass of air entering the engine or intake manifold. 01
Location: It is located between air filter and turbocharger mounted in intake manifold.

iv) Throttle position sensor:
Function: It supplies information to the ECU about the position the throttle is in. 01
Location: Typically mounted on the throttle body or directly to the end of throttle shaft.

c) Compare S.I. and C.I engine on the basis of 04
i) Operating pressure ii) Power output per unit weight
iii) Thermodynamic cycle iv) Compression ratio

Answer: **Comparison of SI and CI Engine-*(1 mark each)*** 04

Parameter	S I Engine	C I ENGINE
i) Operating pressure	Compression pressure is 7bar to15 bar.	Compression pressure is 30bar to50 bar.
ii) Power Output per unit weight	2.7 kg/KW, because of lower compression ratio and lower pressure involved	6.5 kg/KW because of higher compression ratio and higher pressure involved.
iii)Thermodynamic cycle	It work's on Otto cycle.	It work's on Diesel cycle.
iv) Compression Ratio	Compression ratio is low, about 10:1, limited by detonation.	Compression ratio is Higher, about 18:1 to 22:1.

d) With the help of P -θ diagram explain the stages of combustion in S.I. engine. 04

Answer: **The stages of combustion in S.I. engine:**

Stage I: **Ignition Lag or Preparation Phase:**

It is a chemical process which depends on-nature of fuel, temperature & pressure, proportion of exhaust gas, rate of burning and temperature .It is the growth and development of a semi propagating nucleus of flame.(At the moment of spark discharge, the temperature exceeds 10,000°C) 03

i. At the end of this stage, the first rise of pressure (on indicator diagram) can be detected. It is the point where the line of combustion departs from the compression line.
ii. The start of first stage is ignition of charge (a sufficiently homogeneous mixture of vaporized fuel, air & residual gases), leaving behind a thin thread of the flame. From this thin thread combustion spreads to envelop of mixture immediately surrounding it.

Stage II: **Propagation of flame:**

It is a simple, pure and mechanical process. The starting point of the second stage is where first measurable rise of pressure can be seen on the indicator diagram. i.e. the point where the line of the combustion departs from the compression line. During second stage, the flame spreads throughout the combustion chamber. The second stage ends as maximum pressure (on indicator diagram) is reached.

Stage III: **After burning**.

End of second stage means completion of flame travel. But it does not result in complete heat release (burning of fuel).

Even after the passage of flame, some chemical adjustments continue throughout the expansion stroke- near the walls and behind the turbulent flame front. The rate of combustion reduces due to surface of the flame front becoming smaller and reduction in turbulence.

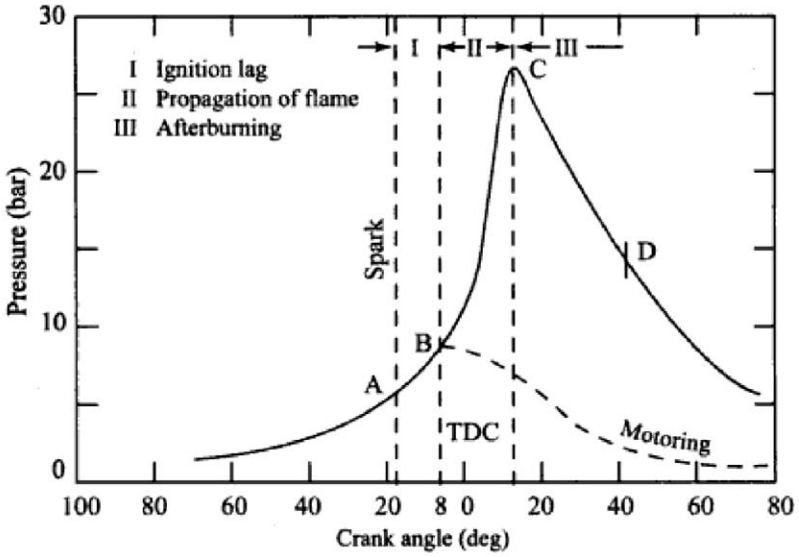
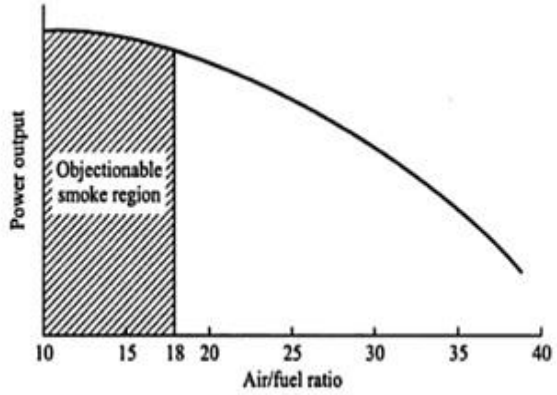
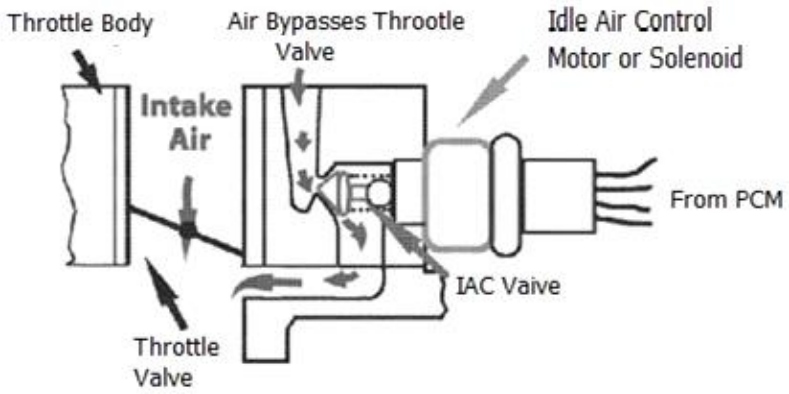


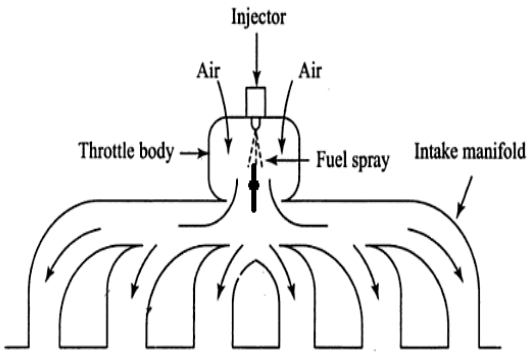
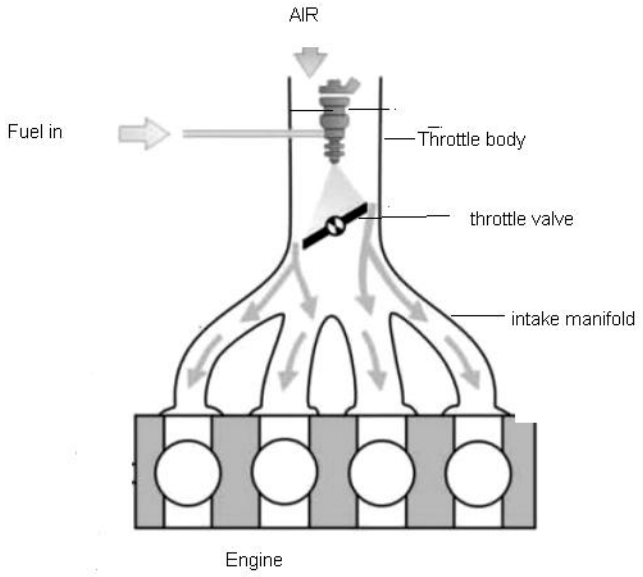
Figure: P- ϴ diagram (Stages of combustion in SI engine) — 01

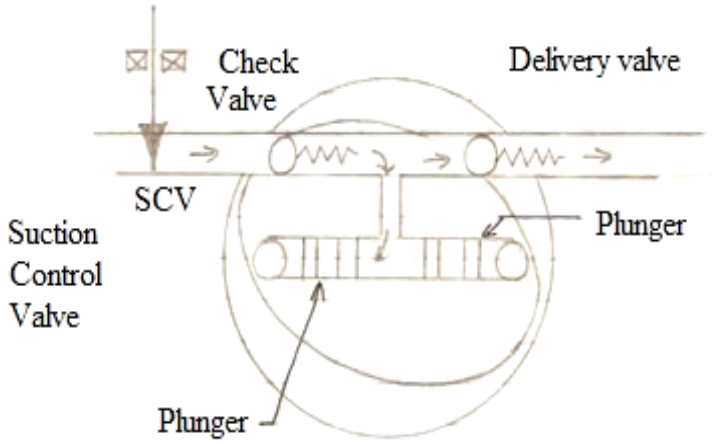
e) State the types of S.I. engine combustion chambers and give advantages of each. — 04

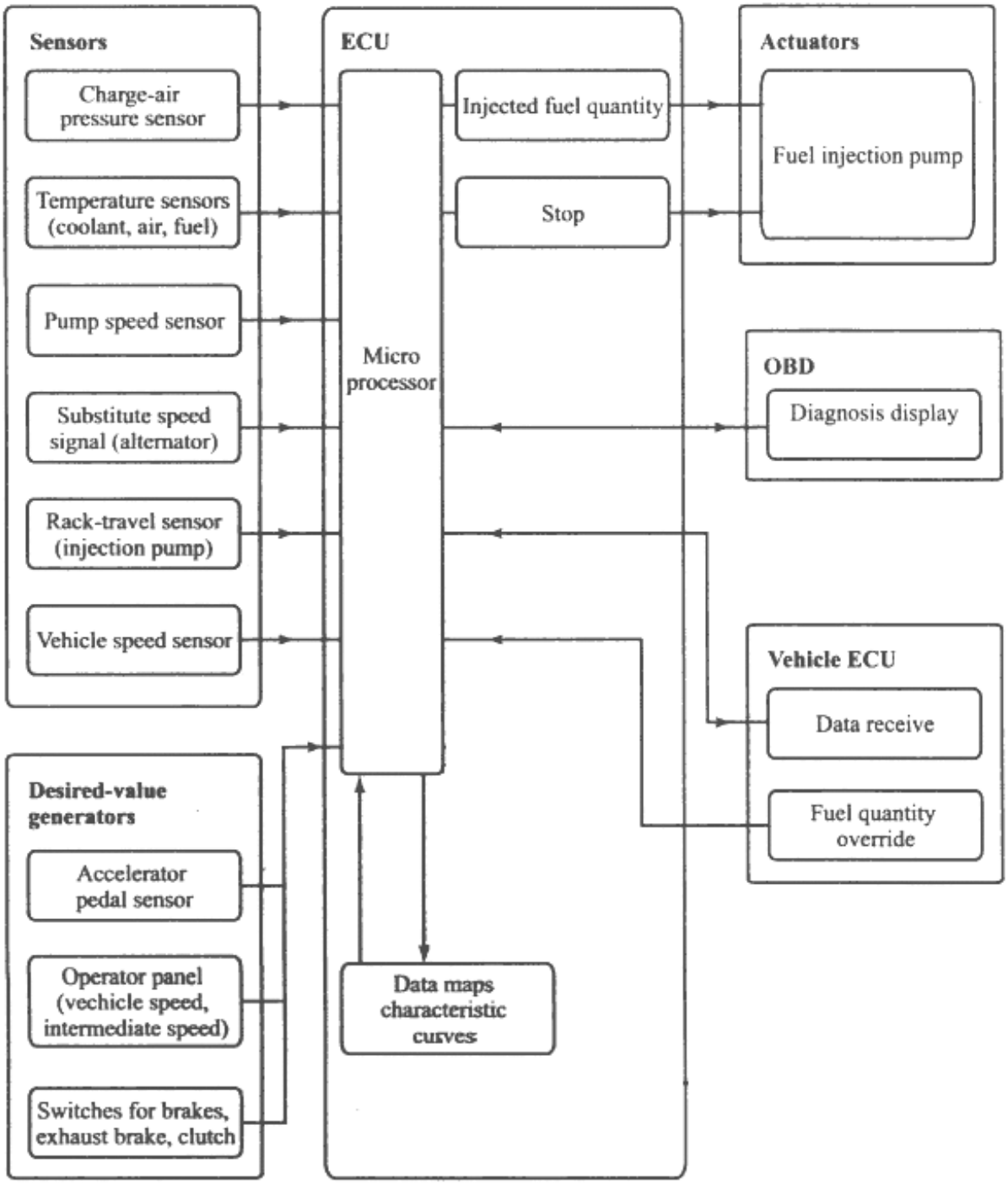
Answer: *Any four types of combustion chamber with one advantage- 01 mark each* — 04

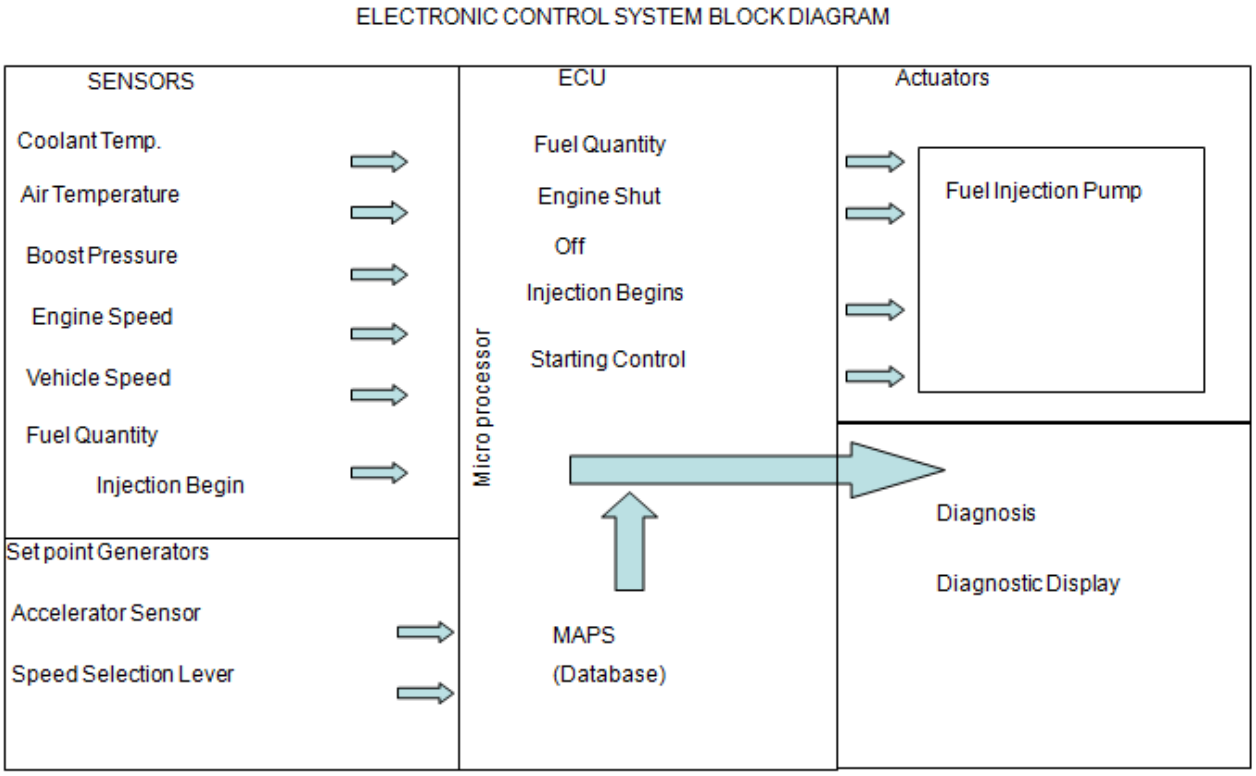
Advantages and drawbacks of S I Engine combustion chambers		
Sr.	Combustion Chamber Type	Advantages
1	T- head combustion chamber	1. Easy to manufacture flat cylinder head, 2. Lower height of engine and front hood for better frontal visibility of vehicle
2	L- head or side head combustion chamber	1. Neat and compact layout 2. Easy to lubricate valves, easy to decarbonize engine.
3	Ricardo Turbulent head side valve combustion chamber	1. Faster flame speed, 2. Reduced detonation 3. Homogeneous air: fuel mixture formation.
4	F- head combustion chamber	1. Flat roof allows use of an inlet valve bigger than exhaust valve. 2. Valve and plug cooling is efficient.
5	I – head combustion chamber (Wedge form and Bath tub form of combustion chamber)	1. Lower pumping losses and higher volumetric efficiency. 2. Lesser distance of flame travel. Therefore low octane requirement. 3. More uniform cooling of cylinder and piston. 4. Lower surface to volume ratio and therefore less heat loss. 5. Easier to cast and hence lower casting cost.

f) Sate the effect of A/F ratio on power output of a C.I. engine with the help of graph.	04
Answer: **Effect of A/F rati**o **on power output of a C.I. engine:** *(02 Marks, Graph- 02 Marks)* Thermodynamic analysis of the engine cycles has clearly established that operating an engine with a leaner air-fuel ratio always gives a better thermal efficiency but the mean effective pressure and the power output reduce. The CI engine is always designed to operate with an excess air, of 15 to 40% depending upon the application. The power output curve for a typical CI engine operating at constant speed is shown in Fig. given below. The approximate region of A/F ratios in which visible black smoke occurs is indicated by the shaded area.  C.I.Engine - Air Fuel Ratio Vs Power Output	02 02
3. Attempt any four of the following:	16
a) Explain idle speed control system as output function of ECM.	04
Answer: **Idle speed control system as output function of ECM:**  Figure: Idle speed control system *(Note: Credit shall be given to any Equivalent diagram)* The idle speed is controlled by a stepper motor that is operated by ECM as a function of engine speed, load and engine temperature. The stepper motor controls the idle passage size i.e. it controls amount of air entering the intake manifold. The fuel injection is controlled by ECM using electronic fuel injector. Thus air: fuel ratio gets controlled by proper fuel with adequate air flow past the Idle Speed Control valve (that is operated by stepper motor).	02 02

Stepper Motor: It rotates a valve shaft either in or out. This in turn increases or decreases the clearance between the valve and the valve seat, thereby regulating the amount of air allowed to pass through. The Idle speed control valve stepper motor allows 125 possible valve opening positions. It is located in the air bypass channel around the throttle valve.	
b) Describe construction and working of TBI system with suitable sketch.	04
Answer: Construction and working of TBI system: Throttle Body Injection is an electronically controlled injection system in which an electronic fuel injector injects the fuel intermittently in to the intake manifold at a central point ahead of the throttle valve. The central- injection unit operates at low pressure (0.7 to 1 bar) so, an inexpensive hydrodynamic electric fuel pump can be used (generally in the form an in-tank unit). The injector is flushed continuously by the fuel flowing through it in order to prevent the formation of air bubbles. The injector is a solenoid – controlled valve. The central injection unit uses the throttle valve to meter the intake air while injecting the fuel intermittently above the throttle valve. The intake manifold then distributes the fuel to the individual cylinders. Various sensors monitor all important engine-operating data, which are then used to calculate the triggering signals for the injectors and other system actuators.  *Fig. Throttle Body Injection (Single Point)*  	02 02
OR	
c) MPFI system is beneficial fuel supply system over carbureted engine. Justify your answer.	04
Answer: MPFI system is beneficial fuel supply system over carbureted engine for the following reasons. **Increased fuel economy**- since equal quantity of fuel is supplied to port for each cylinder, no wall wetting effect as in carbureted engine. **Higher power output**- due to optimized intake manifold design- unlike choked passage of carburetor. **Lower exhaust emission**- as the Lambda Closed loop control system is adopted for steady state operation- unlike approximation in charge supplied by a carburetor. **Improved throttle response**- as the fuel is injected on the backside of hot intake valve and shorter length of travel for fuel to enter the cylinder- as against delayed response by carbureted system. **Detonation control** is possible in MPFI system- it is not possible with carburetor.	04

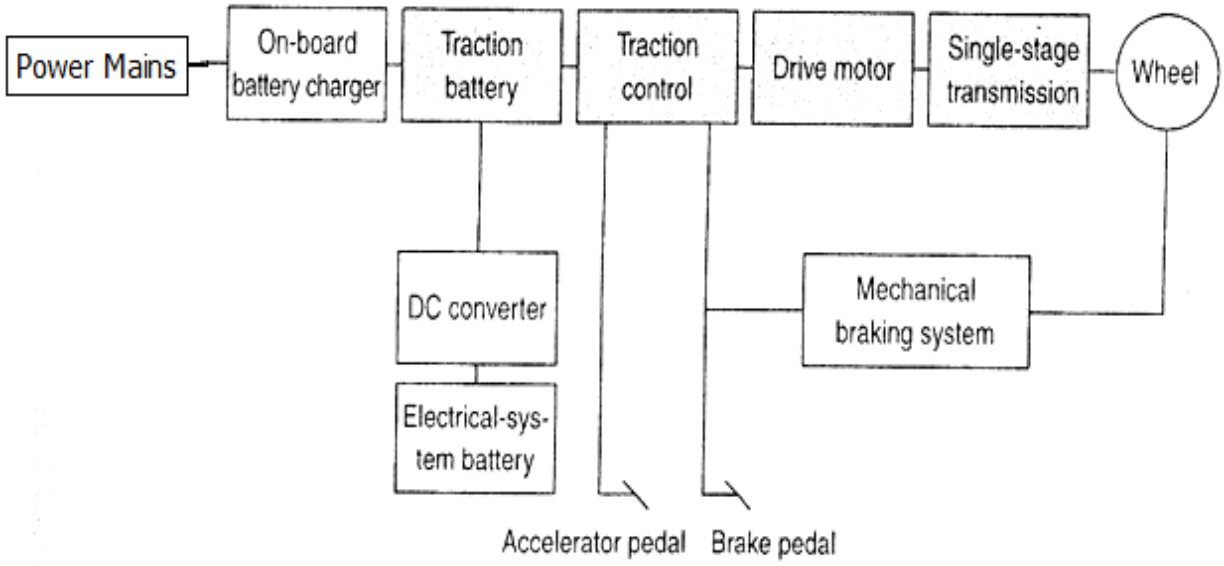
d) What is glow plug? Why and where it is used?	04
Answer: **Glow Plug**: Some diesel engines use an electric heater called glow plug inside the cylinders to heat the intake air and help ignite fuel: air mixture. Glow plug is an aid for cold starting of a C.I. engine. Modern glow plugs heat to required temp in just 4 seconds. **Purpose of using a Glow Plug**: The self ignition temperature of diesel is 250°C. For compression ignition, the charge (air + diesel) should reach a temperature of about 550°C. Cold weather conditions make it difficult to happen. So, a glow plug is used in C.I. Engines. The glow plug heats to starting temperature (approx. 850°C) as rapidly as possible. **Location of Glow Plug**: In Pre-chamber engine, glow plugs are installed which extend into the secondary chamber. On D.I engines, the glow element extends into the main combustion chamber.	01 02 01
e) Describe the working of high pressure fuel pump with neat sketch used in CRDI system.	04
Answer: **Working of High pressure fuel pump used in CRDI system:**  Figure: Sectional view of High Pressure Fuel pump in CRDI system • The fuel inlet to the pump is controlled by the SCV (suction control valve) through the EDC • The rotation of the inner cam pushes the plunger inwards, so that it can pump the fuel. • Plunger outward movement is caused by the pressure of fuel feed pump. Fuel enters the pumping element chamber (intake stroke) • At BDC the check valve closes • The fuel in the chamber is pressurized by the plungers moving inward. • The delivery valve opens and the fuel passes to the common rail. • A constant pressure of about 1400 to 1600 bar is maintained in the common rail.	02 02

f) Draw a labeled block diagram of EDC unit.	04
Answer:  Fig: Block Diagram of EDC Unit **OR**	04



4. A) Attempt any three of the following :	12
a) Draw a labeled block diagram of electric car and state two limitations	04

Answer: **Block Diagram of an Electric Car:** *(Diagram- 02 Marks, Limitations – 02 Marks)*



02

OR

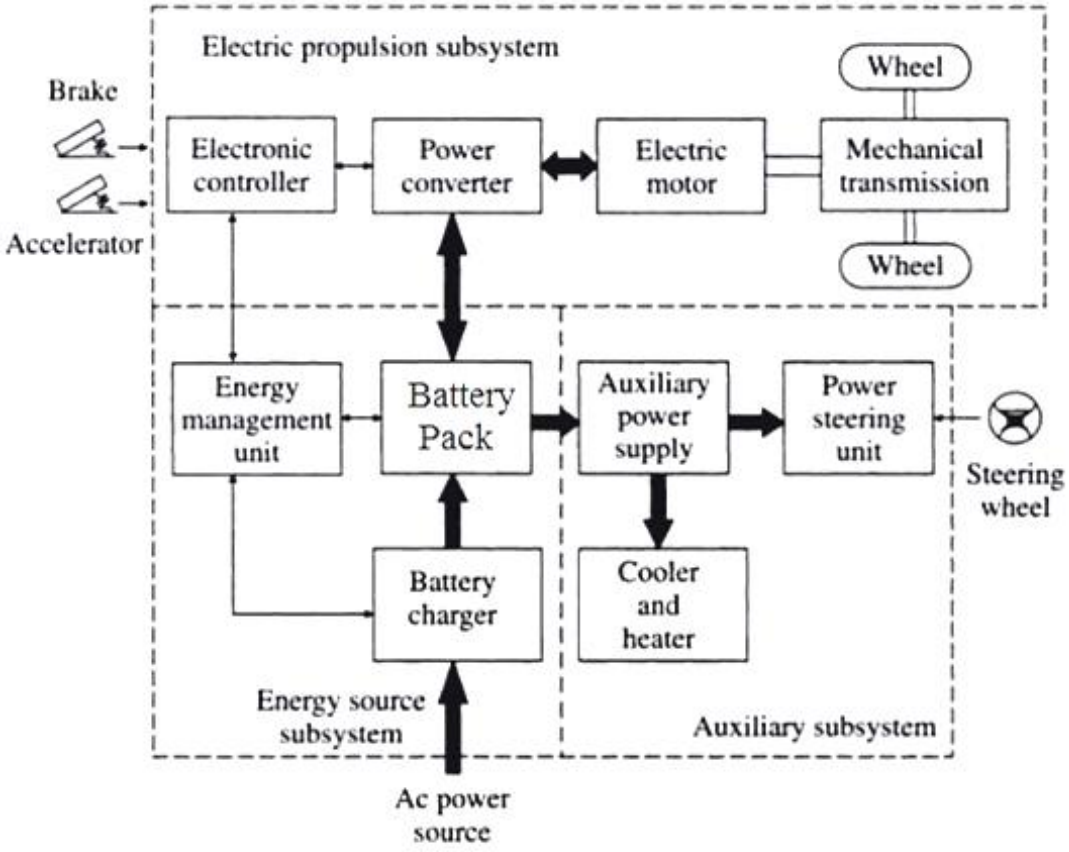


Figure: Block Diagram of an Electric Car

02

Note: Similar block diagram should be credited

Limitations of Electric Car (2 marks, Any 2)

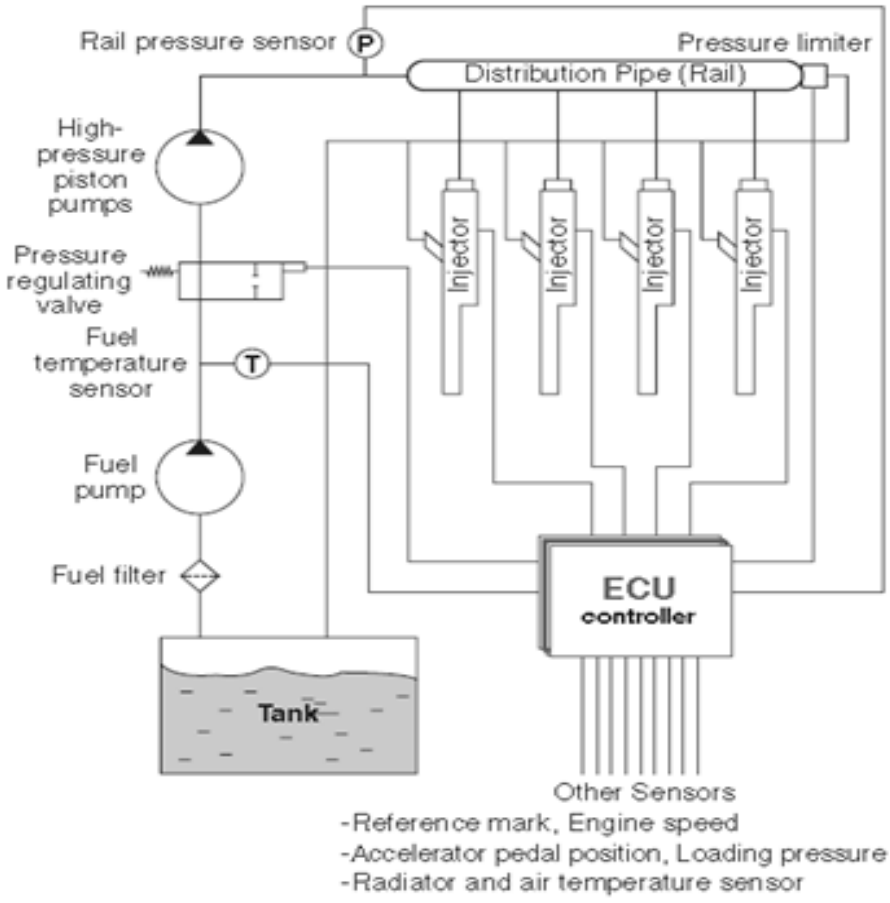
1. Need to charge the batteries.
2. The top speed is quite low.
3. Life of batteries quite short
4. More expensive to replace the batteries.
5. Not suitable for heavy vehicles
6. Limited power.

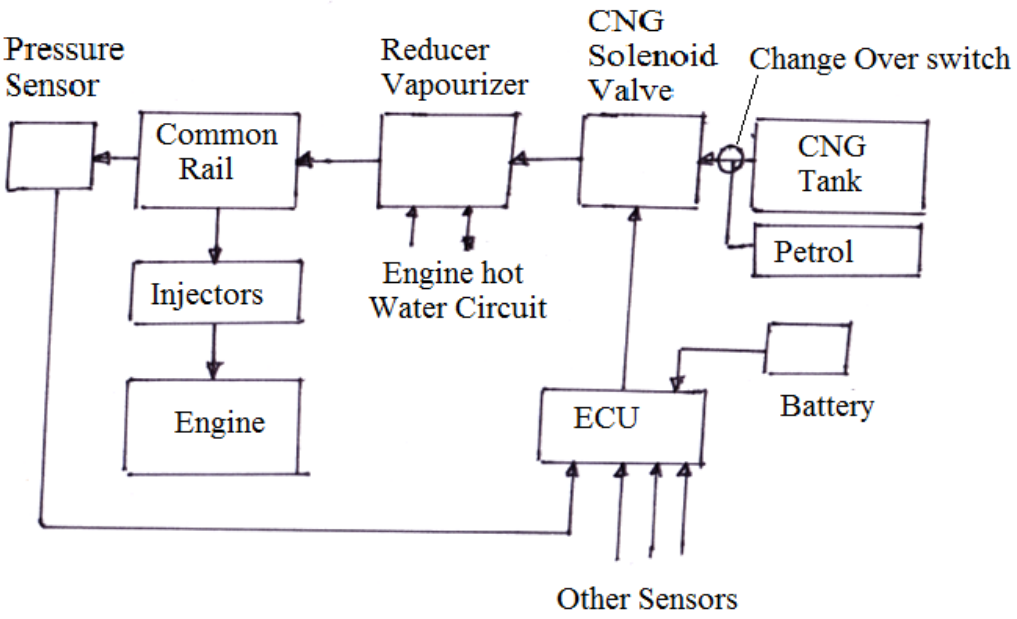
b) List advantages and disadvantage of LPG (Two each) 04

Answer: **Advantages of LPG**: *(Any Two- 02 Marks)* 02

1. It is cheaper than petrol
2. It is highly detonation resistant and does not pre-ignite easily.
3. It gives better manifold distribution and mixes easily with air.
4. Crankcase oil dilution is less/ nil, resulting in increased engine life.
5. Residue and oil contamination is small as it burns cleanly: implies longer lubricating oil change period.
6. LPG is lead free – implies- less exhaust emission.
7. Life of spark plug is increased.

Disadvantages of LPG ***(Any Two- 02 Marks)*** 1. It reduces volumetric efficiency due to its high heat of vaporization. 2. Handling has to be done under pressure of about 18 bars. 3. It characteristic odour is faint. An odourant (usually Mercaptan) is usually added so that the people will be aware of the leaks. 4. Much of its advantages can be realized (obtained) in engines of higher compression ratio. 5. Response to blending is very poor. 6. LPG produces 10 % less power for a given engine, at full throttle. 7. The vehicle weight is increased due to the use of heavy pressure cylinders for storing LPG. 8. A special fuel feed system is required for LPG. 9. Reduced Boot space (Storage tank occupies part of the Boot space) 10. Unlike petrol pumps, LPG filling stations are less in number. (Most of the stations are located in cities). Therefore users inconvenience. 11. Operating range (Running Range) is less as compared to that of petrol. 12. Starting problem with LPG 13. It is safe only if proper periodic maintenance of the gas system is done by trained person.	02
c) CNG is used as a fuel for petrol vehicle. Justify your answer.	04
Answer: **CNG is used as a fuel for petrol vehicle**: Properties of CNG are as follows - 1. ***Self Ignition Temperature*****: *540°C***. Such a high temperature can be quickly obtained by using a spark plug of petrol vehicle. 2. ***Octane number: 130***. So, it is superior to petrol. And the anti- knock additives are not required. Vehicles designed specifically to run on natural gas has no loss of power and may even have greater power and efficiency. NG has Octane number = 130, compared with 87 to 96 Octane number of Petrol. 3. ***Compression ratio used in petrol engine vehicle: 11.5:1***. Being a gaseous fuel, CNG mixes with air easily and evenly. Almost any petrol / diesel vehicle can be converted to operate on CNG. 4. ***Low emission engine***.CNG vehicles also emit very low levels of carbon monoxide (approx. 70 % lower than comparable petrol vehicles) Above properties suggest that CNG is a suitable fuel for S.I. engine. i.e. a spark plug is necessary to ignite the charge in the combustion chamber of I.C. Engine. Further, the compression ratio used in S.I. engine is close to what is required to benefit from the higher octane rating of CNG.	04
d) What is meant by VTEC? State its two advantages.	04
Answer: VTEC stands for Variable valve timing and electronic lift control. **In VTEC, the valve timing and the valve lift is controlled using ECU to provide efficient breathing of engine and efficient performance of engine.** **Advantages:** *(Any Two-2 marks)* 1) Increased fuel efficiency and 2) High power output. 3) Emissions levels can also be more accurately controlled with the GDI system. 4) Improved Volumetric Efficiency	02 02

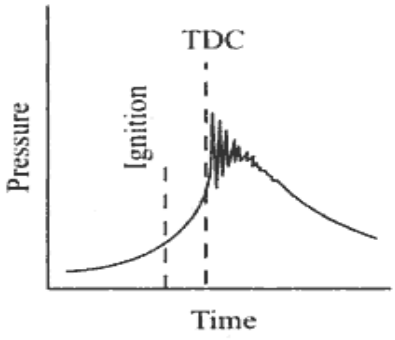
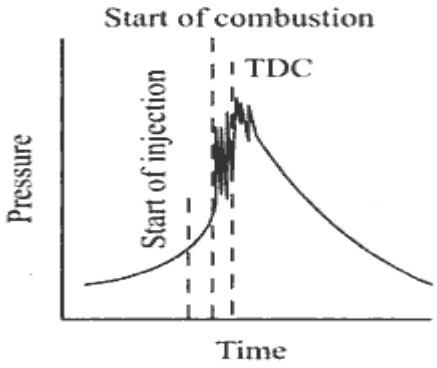
5) GDI allows a high compression ratio of 12, and thus improved combustion efficiency 6) GDI is capable of using very lean mixture i.e. 65:1 while using VTEC 7) Improve drivability.	
4. B) Attempt any one of the following :	06
a) Describe the operation of CRDI system	06
Answer: **Operation of CRDI system:**  **Figure** A common rail fuel injection system. The CRDI system works at consistent high pressure availed by high pressure pump. It consists of three major parts - A high pressure pump, Unit injector, A common rail accumulator. Unit injector has a control plunger above needle valve, control spring and a solenoid. The solenoid valve is mounted horizontally on the top of unit injector. The common rail accumulator is plumbed in between high pressure pump and the unit injector. **Working of CRDI engine:** High pressure pump provides high pressure fuel to the common rail. The common rail stores the fuel and maintains a constant pressure in the common rail line (approximately 1500 bars.). This pressure is continuously available at injectors.	02 04

The injection pressure is independent of engine speed. The quantity of fuel injected in the combustion chamber is controlled by actuating solenoid valve in the injector. As solenoid is energized, injection begins. Injector pulse width, multiple injections and duration of injection – all are controlled by EDC of CRDI system. The system pressure is controlled by means of a pressure sensor. Pilot injection and possibly a second, third injection is achieved by repeatedly activating solenoid valve, whereas the injection rate can be modified by controlling the nozzle needle movement.	
b) Explain the working of CNG conversion kit with a labeled block diagram.	06
Answer: **Working of CNG conversion kit:**  Figure: CNG Kit **Working of CNG Kit:** The Sequential Injection system still has a high pressure tank, filler, filter and regulator, the regulator is different in that it puts out a steady pressure as opposed to variable pressure. The Natural Gas is then injected by natural gas injectors which are controlled by the gasoline injector pulse. This system also uses its own MAP (manifold absolute pressure) sensor, natural gas pressure sensor, natural gas temperature sensor and coolant temperature sensor to operate and control the system.	03 03
5. Attempt any two of following :	16
a) Compare detonation and knocking with the help of P - θ diagram and give the methods to control both.	08

Answer: **Comparison of detonation and knocking:** ***(****Comparison: any 4 points – 1mark each; P- Θ diagram- 2 marks, Control method - one each =2 marks)*

Sr.	Detonation in S I Engine	Knock in C I Engine
1	Detonation occurs near the end of combustion	Knocking occurs near the beginning of combustion. i.e. at the end of first stage of combustion.
2	Detonation in S I Engine is of a homogeneous charge causing very heavy rate of pressure rise and high maximum pressure.	Knocking in C I engine is of imperfectly mixed charged and hence the rate of pressure rise is normally lower than that in the detonation in S I Engine.
3	Pre-ignition may occur.	Fuel is injected into the cylinder only at the end of the compression stroke and there is no question of pre- ignition or premature ignition.
4	Detonation is easily distinguished from normal combustion.	Knocking is not easy to distinguish from normal combustion.
5	Larger cylinder promotes detonation	Diesel knock is reduced with increase in size of cylinder.
6	Compression ratio in S.I. engine is limited by Detonation	In C.I. engines, higher compression ratio causes lesser ignition delay and hence lesser possibility of diesel knock.

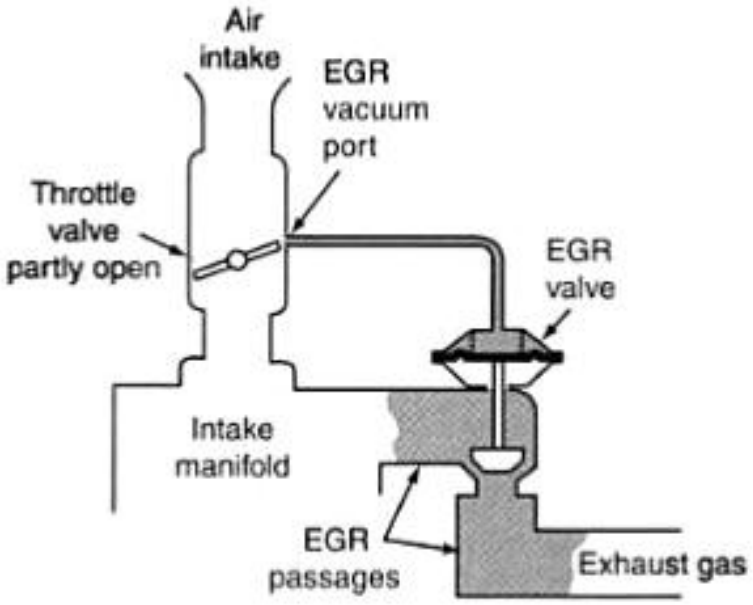
04

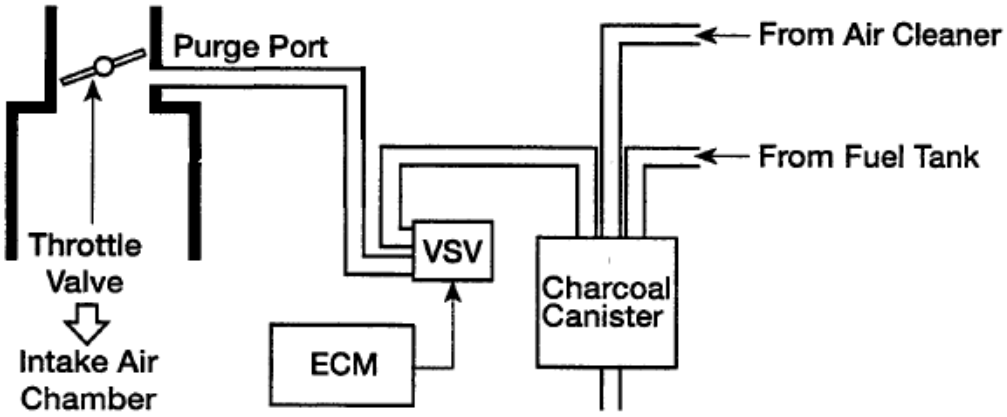
P- Θ diagram		

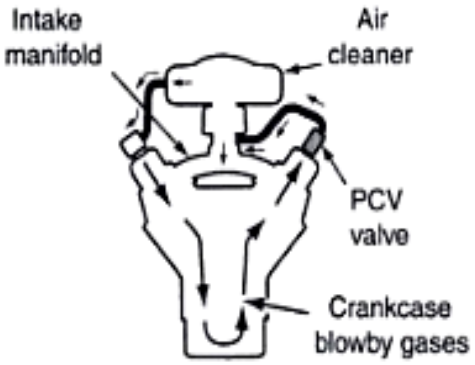
02

Control methods **(1 each)**	1. Increasing engine rpm. 2. Retarding spark timing 3. Reducing pressure in inlet manifold by throttling. In supercharged engines reducing supercharging pressures reduces detonation. 4. Making the ratio too lean or too rich, preferably latter. 5. Water injection.	Knocking can be reduced by reducing delay period. i.e. 1. By High charge temperature; 2. High fuel temperature; 3. Good turbulence; 4. By using ignition accelerators like amyl nitrate.

02

b) Illustrate the method to control NO_x with the help of neat sketch.	08
Answer**: Method to control NO_x :** The EGR system is used to reduce the amount of NO_x in the exhaust. NO_x production increases as the temperature inside the combustion chamber rises due to acceleration or heavy engine loads, because high temperature encourages the nitrogen and oxygen in air to combine. Therefore, the best way to decrease the production of NO_x is to hold down the temperature in the combustion chamber. The EGR system re-circulates exhaust gases through the intake manifold in order to reduce the temperature at which combustion takes place. When the air: fuel mixture & exhaust gases are mixed together, the proportion of fuel in the air: fuel mixture naturally falls (mixture becomes leaner), & in addition, some of the heat produced by combustion of this mixture is carried away by the exhaust gas. The maximum temperature attained in the combustion chamber therefore falls, reducing the amount of NO_x produced. The EGR system allows a small amount of exhaust gas (less than 10% of total) to be supplied into the incoming air: fuel mixture.  Fig: Exhaust gas recirculation system controls the amount of exhaust flowing back into the intake manifold	04 04
c) Illustrate the system to control evaporative emissions with a neat sketch.	08
Answer: **System to control evaporative emissions:** **EVAP system Operation:** When the engine is running, stored fuel vapours in fuel tank are purged from the canister whenever the throttle has opened past the purge port and coolant temperature is above 54 °C. Fuel vapours flow from the high pressure area in the canister, past check valve in the canister, through the vacuum switching valve (ECM controlled- duty cycle controlled), to the low pressure area in the throttle body. ECM uses engine speed, intake air volume, coolant temperature, and oxygen sensor information to control EVAP operation.	04

Atmospheric pressure is allowed into the canister through a filter located on the bottom of the canister. This ensures that the purge flow is constantly maintained whenever purge vacuum is applied to the canister. When coolant temperature falls below 35°C, the vacuum switching valve prevents purge from taking place by blocking the vacuum signal to the check valve at canister. Under other conditions, as fuel is drawn from the tank, a vacuum may be created in the tank. This is prevented by allowing atmospheric pressure to enter the tank through the check valve in the charcoal canister or fuel tank cap check valve. The EVAP system is designed to limit maximum vacuum and pressure in the fuel tank.  VSV: Vacuum Switching Valve ECM: Electronic Control Module Figure: Evaporative Emission Control system *Note: Equivalent credit shall be given to any other suitable diagram.*	04
6. Attempt any four of the following :	16
a) How DTSI is beneficial over conventional ignition?	04
Answer: This technology provides a combination of the light weight and twice the power offered by two-stroke engines with a significant power boost, i.e. a considerable "power-to-weight ratio" compared to quite a few four-stroke engines. Moreover, such a system can adjust idling speed & even cuts off fuel feed when the accelerator pedal is released, and meters the enrichment of the air-fuel mixture for cold starting and accelerating purposes; if necessary, it also prevents the upper rev limit from being exceeded. At low revs, the over boost is mostly used when overtaking, and this is why it cuts out automatically. At higher speeds the over boost will enhance full power delivery and will stay on as long as the driver exercises maximum pressure on the accelerator. **Benefits of DTSI system over conventional Ignition system are as follows**. 1. Less vibrations and noise. 2. Long life of the engine parts such as piston rings and valve stem. 3. Decrease in the specific fuel consumption. 4. No overheating. 5. Increase the Thermal Efficiency of the Engine & even bear high loads on it. 6. Better starting of engine even in winter season & cold climatic conditions or at very low temperatures because of increased Compression ratio. Because of twin Sparks the diameter of the flame increases rapidly that would result in instantaneous burning of fuels. Thus force exerted on the piston would increase leading to better work output.	04

b) What is meant by diesel smoke? State two methods to control the same.	04
Answer: Diesel smoke: Smoke is defined as visible products of combustion, is due to poor combustion. It originates early in the combustion. Rich fuel-air mixture & at pressures developed in diesel engines- produces soot. If soot is not burnt in combustion cycle it will pass in exhaust, & if in sufficient quantity, will become visible- as smoke. **Methods of controlling diesel smoke: (Any 2 methods- 02 marks)** 1. **De-rating:-** At lower loads, the air: fuel ratio obtained will be leaner & hence the smoke developed will be less. However this means a loss of output. 2. **Maintenance:** - Maintaining the injection system of engine properly results in a significantly reduced smoke, Best engine performance, Clean exhaust system. Other methods are changes in Combustion chamber geometry. 3. **Smoke suppressant additives:-** Some barium compound, if used in fuel, reduce the temp of combustion, thus avoiding the soot formation, & if formed- they break it into the fine particles, thus appreciably reducing smoke. 4. **Fumigation**:- Fumigation consists of introducing a small amount of fuel into the intake manifold. This shortens the delay period- curbs thermal cracking which is responsible for soot formation.	02 02
c) Explain the working of PCV system with neat sketch.	04
Answer: Working of PCV system: . During normal compression stroke, a small amount of gases in the combustion chamber escapes past the piston. Approximately 70 % of these 'blow-by' gases are unburned fuel (HC) that can dilute and contaminate the engine oil, cause corrosion to critical parts, and contribute to sludge build up. At higher engine speeds, blow-by gases increase crankcase pressure that can cause oil leakage from sealed engine surfaces. The purpose of PCV system is to remove these harmful gases from the crankcase before damage occurs and combine them with the engine's normal incoming air: fuel mixture. PCV system uses a variable flow PCV valve accurately matches ventilation flow with blow-by production characteristics. By accurately matching these two factors, crankcase ventilation performance is optimized, while engine performance and drivability remains unaffected.  Figure: Positive Crankcase Ventilation System OR	02

d) Why and where catalytic convertor is used? Give chemical reactions for the same.	04
Answer: **Reason for using catalytic convertor:** Catalytic converter is used in a vehicle (exhaust system) to convert undesirable exhaust gases into harmless gases. As part of the exhaust system, it also helps reduce the noise level of the exhaust. The three-way or selective catalytic converter with lambda closed- loop control has proven to be an effective concept for exhaust –gas after treatment. It is capable of providing the required reduction of all three pollutants (NO_x, CO and HC) The converter if operated at temperature of approx. 400…800°C, provided the engine is operated with a nearly stoichiometric mixture (λ= 0.99 to 1.) gives maximum conversion efficiency and extended service life. **Location of Catalytic convertor:** Installing the catalytic converter directly adjacent to the engine provides benefits in the form of high exhaust – gas temperature, resulting in optimum efficiency, but with the disadvantage of high thermal stresses. As the maximum permissible operating temperature is reached just slightly above 1000^0C, the units are generally installed at a less critical location under the floor of the vehicle. **Chemical Reactions** *(Any two reactions -1 mark)* **1)** the reduction of nitrogen oxides 2NOx(g) → xO2(g) + N2(g) x can be 1 or 2 as in NO(g) or NO2(g) 2) the oxidation of poisonous carbon monoxide to carbon dioxide 2CO(g) + O2(g) → 2CO2(g) 3) Oxidation of unburnt hydrocarbons (HC) to carbon dioxide and water: $C_xH_{2x+2} + [(3x+1)/2]O_2 \rightarrow xCO_2 + (x+1)H_2O$.	02 01 01
e) List the methods of improve fuel economy.	04
Answer: Methods to improve fuel economy: *(Any four methods- 4 marks)* 1) Use of multi-functional fuel additives will provide 3 to 4% fuel economy. 2) Good driving habits. 3) Properly maintained fuel supply system. 4) Use of computer controlled fuel injection system. 5) Use of computer controlled ignition system. 6) Use of higher voltage automotive electrical system (42 volts system)	04