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 judgement 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.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1	A)	**Attempt any THREE of the following:**	12
	a)	**Define 'Combustion 'State the three general conditions necessary for combustion**	4
		Answer: (*Defination: 1 Marks,1 marks for each condition*) Combustion: It may be define as a relatively rapid chemical combination of hydrogen and carbon in the fuel with the oxygen in the air resulting un liberation of energy in the form of heat. **Conditions necessary for combustion:** 1) The pressure of the combustible mixture. 2) Some means to initial mixture. 3) Stabilization and propagation of flame in the combustion chamber.	4
	b)	**List the drawback of carburetor.**	4
		Answer: *(1 mark for each point*) 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.	4

		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) Carburetor Icing may take place.	
	c)	**List any four components used in CRDI system.**	**4**
		Answer: (*1 mark for each components*) 1. High pressure Fuel pump 2. High pressure accumulator 3. Injectors 4. Engine control unit 5. Fuel filter	4
	d)	**State the need of Hybrid Vehicles. Write two advantages of the same.**	**4**
		Answer: **Need of Hybrid Vehicle :** (*any four*) 1) To increase fuel efficiency. 2) To reduce gaseous emission. 3) To increase acceleration capability. 4) To reduce noise emission. 5) To reduce fuel consumption.	2
		Advantage: (*Any Two*) 1) Environmentally friendly. 2) Financial Benefits. 3) Less dependence on Fossil Fuels 4) Regenerative braking system. 5) Built from light Materials.	2

	B)	**Attempt any ONE of the following:**	**06**
	a)	**State three methods of fuel injection used in MPFI system. Describe any one.**	**06**
		Answer: *(Methods : 2 marks, Description of any one : 4 Marks credit shall be given to suitable diagram)* **Methods of petrol injection** 1. Sequential fuel injection. (SFI) 2. Grouped fuel injection. 3. Simultaneous fuel injection 4. Continuous injection. 1) **Simultaneous Injection:** Injection of fuel occurs at the same time for all cylinders every revolution of the crankshaft. Therefore, fuel is injected twice within each four-stroke cycle. The injection timing is fixed with respect to crank/ cam shaft position. 2) **Group Injection**: The injectors are divided into two groups that are controlled separately. Each group injects once per four-stroke cycle. The offset between the groups is one crankshaft revolution. This arrangement allows. 3) **Sequential Injection:** Each injector is controlled separately. Injection timing, both with reference to crank/ camshaft position and pulse width, can be optimized for each individual cylinder. 4) **Continuous injection:-**This system usually has a rotary pump. The pump maintains a fuel line gauge pressure of about 0.75 to 1.5 bar. The system injects the fuel through a nozzle located in manifold immediately downstream of the throttle plate. In supercharged engine, fuel is injected at the entrance of the supercharger. The timing and duration of the fuel injection is determined by ECU depending upon load and speed.	2 04

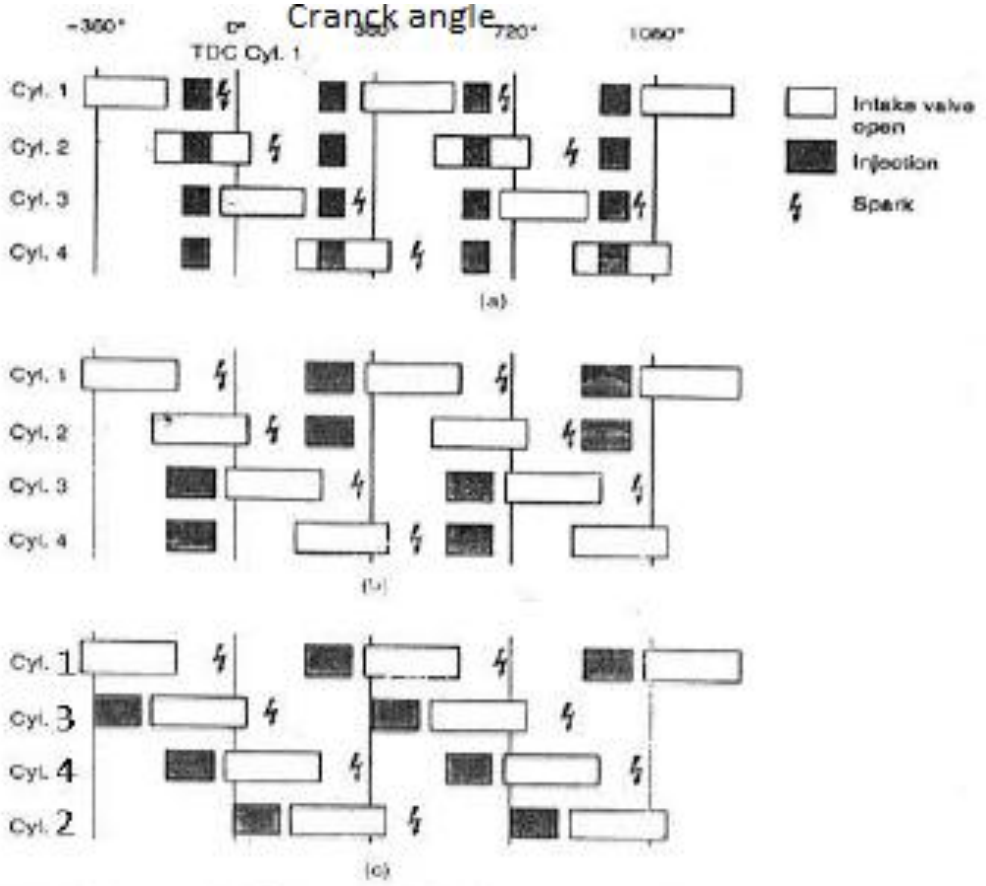
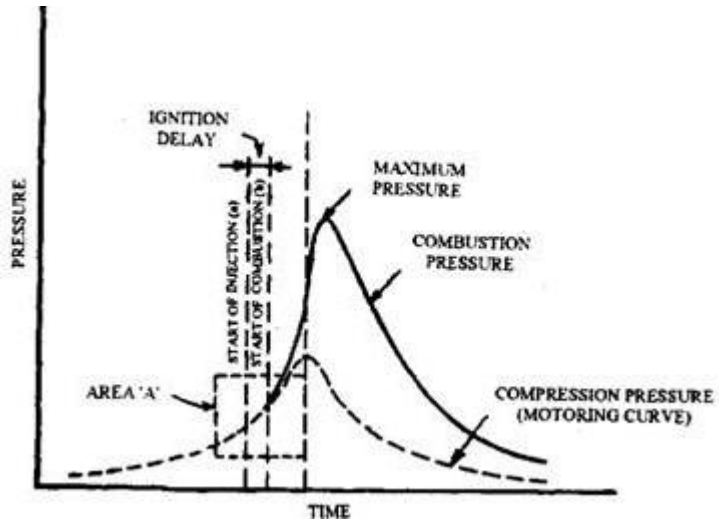


FIGURE Fuel injection strategies: (a) simultaneous injection, (b) group injection, and (c) sequential injection.

Note: Above diagram refers to the first three methods of injection, for continuous injection diagram is not needed.)

	b)	**Draw a pressure-time diagram illustrating delay period. Describe Physical and Chemical delay.**	**6**
		Answer: (*Diagram: 4 marks description: 2 marks)* **Physical Delay:** - The period of physical delay is the time between the beginning of injection and the attainment of the chemical reaction conditions. In this physical delay period the fuel is atomized, vaporized, mixed with air, and raised to its self-ignition temperature. This physical delay depends on the type of fuel, i.e. for light fuel the physical delay is small while for heavy viscous fuels the physical delay is high. The physical delay is greatly reduced by using high injection pressure, high combustion chamber temperature and high turbulence to facilitate breakup of the jet and improve evaporation. **Chemical Delay:** During the chemical delay, reaction starts slowly and then accelerates until the	4

		ignition take place. Generally, the chemical delay is larger than the physical delay. However, it depends on the temperature of the surrounding and at high temperature, the chemical reaction is faster and the physical delay becomes longer than the chemical.  **Figure: Pressure-time diagram**	2
2		**Attempt any FOUR of the following:**	**16**
	a)	**Describe any two variable affecting detonations.**	**4**
		Answer: *(2 marks for any two variable)* **Variable affecting detonations.** 1. **Temperature :** Increasing the temperature of the unburned mixture increase the possibility of knock in the SI engine following are the effect on SI engine parameters on the temperature of the unburned mixture: 1. Increasing the compression ratio increases both the temperature and pressure. 2. Supercharging. Also increase both temperature and density, which increase the knocking tendency of engine. 3. Delay period decreases with increase of coolant temperature, decreased delay period increase the tendency to knock. 2. **Density :** Increasing the density of unburnt mixture will increase the possibility of knock in the Engine. The engine parameters which affect the density are as follows: • Increased compression ratio increase the density. • Increasing the load opens the throttle valve more and thus the density. • Supercharging increase the density of the mixture.	4

- Increasing the inlet pressure increases the overall pressure during the cycle. The high pressure end gas decreases the delay period which increase the tendency of knocking.
- Advanced spark timing: quantity of fuel burnt per cycle before and after TDC position depends on spark timing. The temperature of charge increases by increasing the spark advance and it increases with rate of burning and does not allow sufficient time to the end mixture to dissipate the heat and increase the knocking tendency

3. **Time:** Increasing the time of exposure of the unburned mixture to auto-ignition conditions increase the possibility of knock in SI engines.
   - Flame travel distance: If the distance of flame travel is more, then possibility of knocking is also more. This problem can be solved by combustion chamber design, spark plug location and engine size. Compact combustion chamber will have better anti-knock characteristics, since the flame travel and combustion time will be shorter. Further, if the combustion chamber is highly turbulent, the combustion rate is high and consequently combustion time is further reduced; this further reduces the tendency to knock.
   - Location of sparkplug. A spark plug which is centrally located in the combustion chamber has minimum tendency to knock as the flame travel is minimum. The flame travel can be reduced by using two or more spark plugs.
   - Location of exhaust valve. The exhaust valve should be located close to the spark plug so that it is not in the end gas region; otherwise there will be a tendency to knock.
4. **Composition :**
   - Molecular structure: Increasing the carbon-chain increases the knocking tendency and centralizing the carbon atoms decreases the knocking tendency. Unsaturated hydrocarbons have less knocking tendency than saturated hydrocarbons.
   - Air-fuel mixture: A too rich mixture is especially effective in decreasing or eliminating the knock due to longer delay and lower temperature of compression.
   - Humidity of air: Increasing atmospheric humidity decreases the tendency to knock by decreasing the reaction time of the fuel

b) Compare carbureted engine fuel supply system with MPFI system. **4**

Answer: *(four points- 1 mark each)*

Sr. No.	Carbureted fuel supply system	MPFI fuel supply system
1	Mal-distribution of charge.	Uniform distribution of charge.
2	Due to resistance in intake manifold volumetric efficiency is lower.	Improvement in volumetric efficiency due to less resistance in the intake manifold.
3	Inaccurate metering of charge.	Accurate metering of charge.
4	Carburetor Icing may take place.	Formation of ice on the throttle plate is eliminated.
5	Fuel atomization depends upon velocity of air in the venture.	Atomization of fuel is independent of cranking speed therefore cranking is easier
6	Less atomization and vaporization will make the engine more knock prone.	Better atomization and vaporization will make the engine less knock prone.
7	Fuel need to be more volatile	Less volatile fuel can be used.
8	Fuel injection is take place inside the manifold.	fuel being injected into or close to the cylinder.

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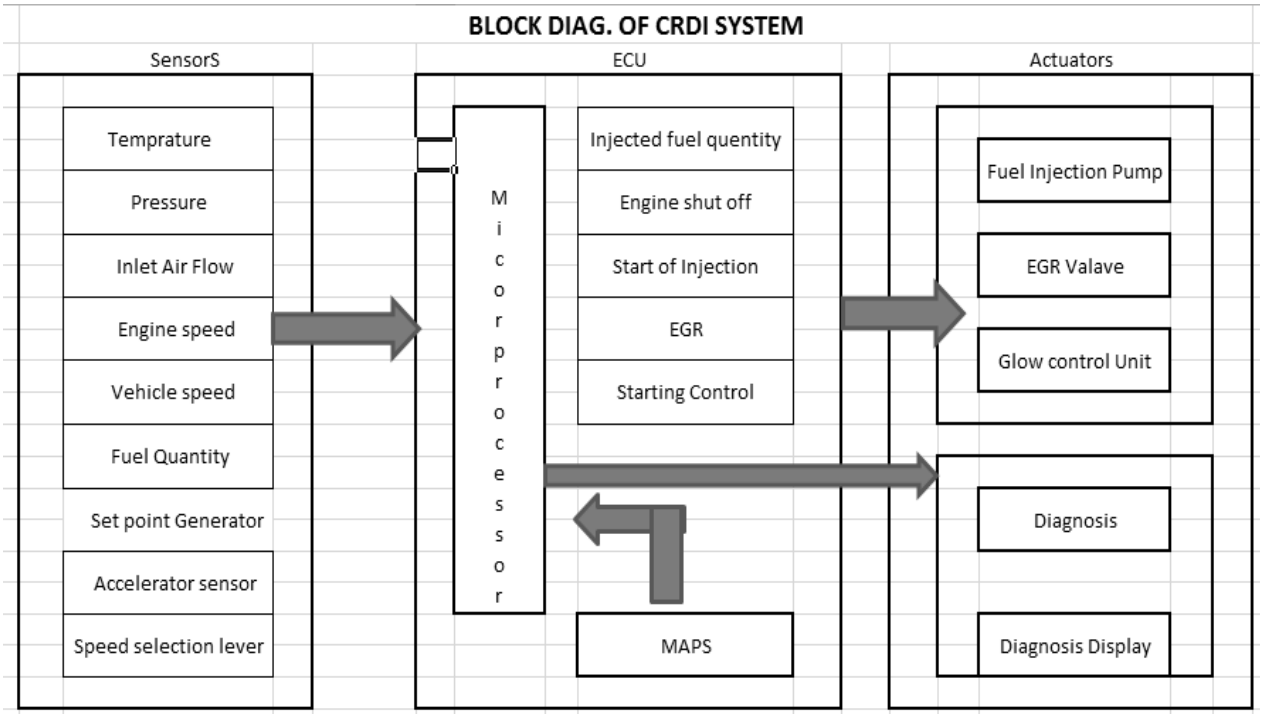
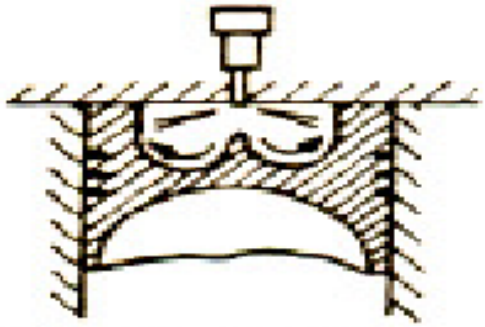
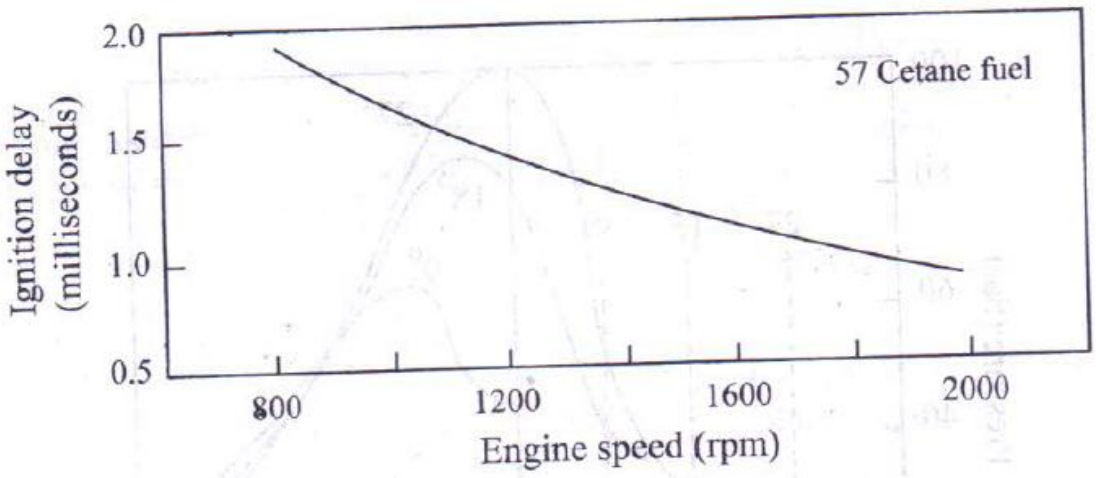
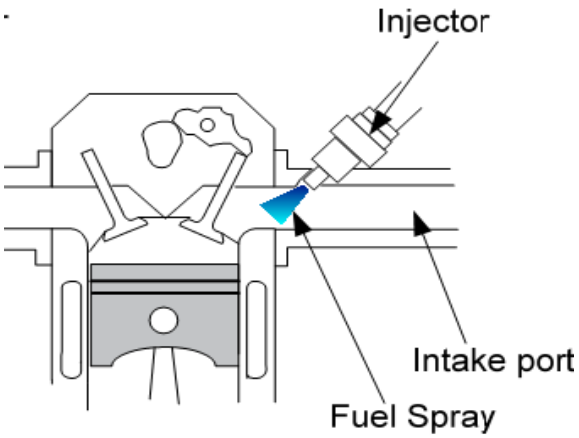
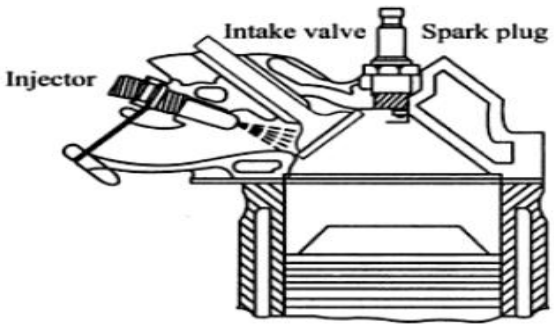
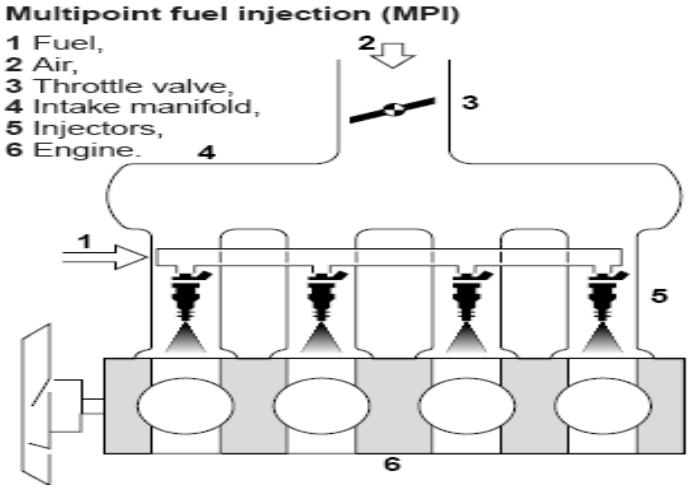
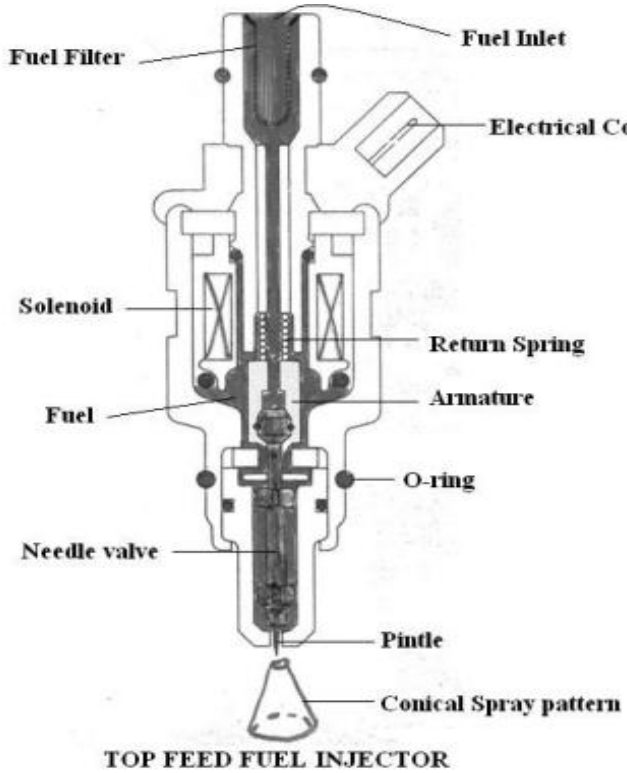
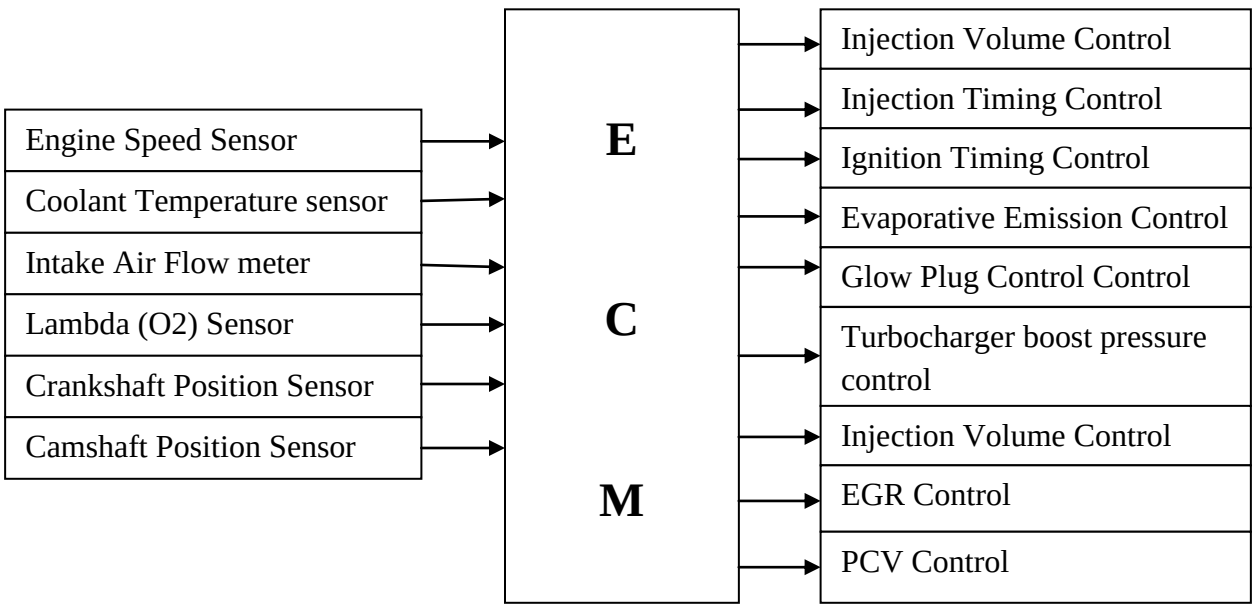
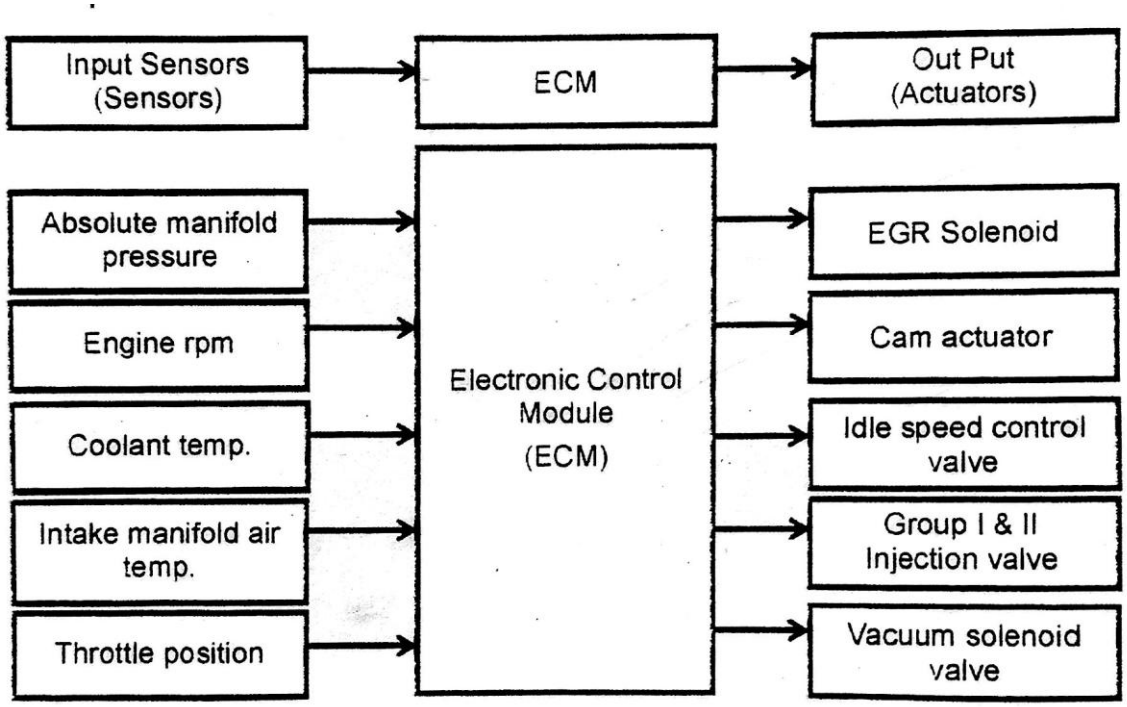
	c)	**Draw a neat labeled block diagram of CRDI system.**	**4**
		Answer: 	4
	d)	**Compare S. I and C. I. engine on the basis of** **i) Power output per unit weight** **ii) Acceleration** **iii) Fuel Economy** **iv) Reliability**	**4**
		Answer:	4

Parameter	S.I. Engine	C.I. Engine
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.
Acceleration	Higher acceleration	Lower acceleration
Fuel Economy	More in Fuel Economical	Less in Fuel Economical
Reliability	More in Reliable	Less Reliable

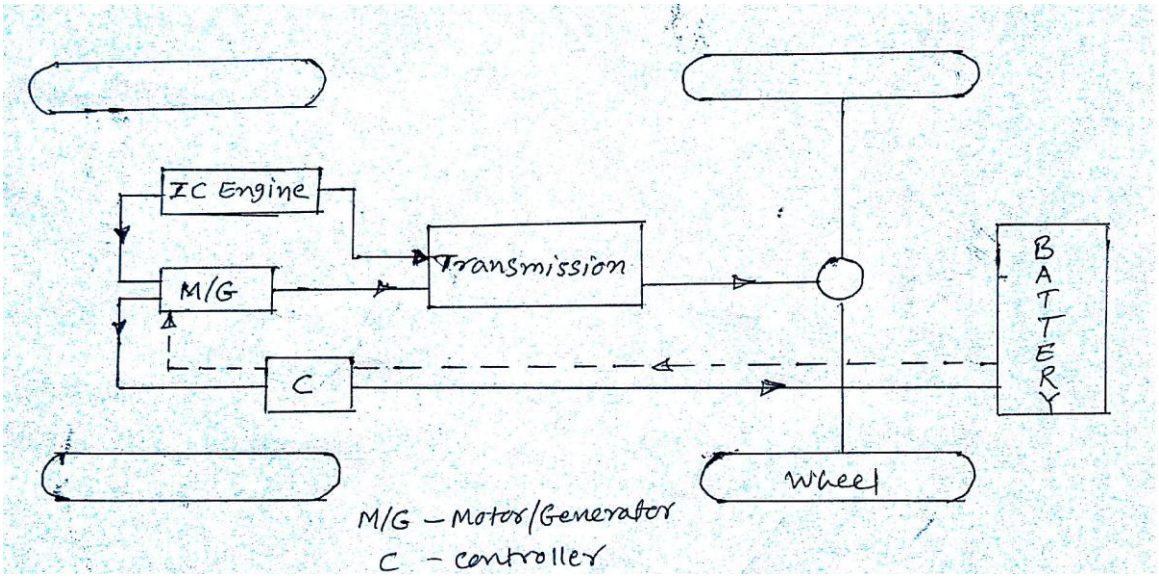
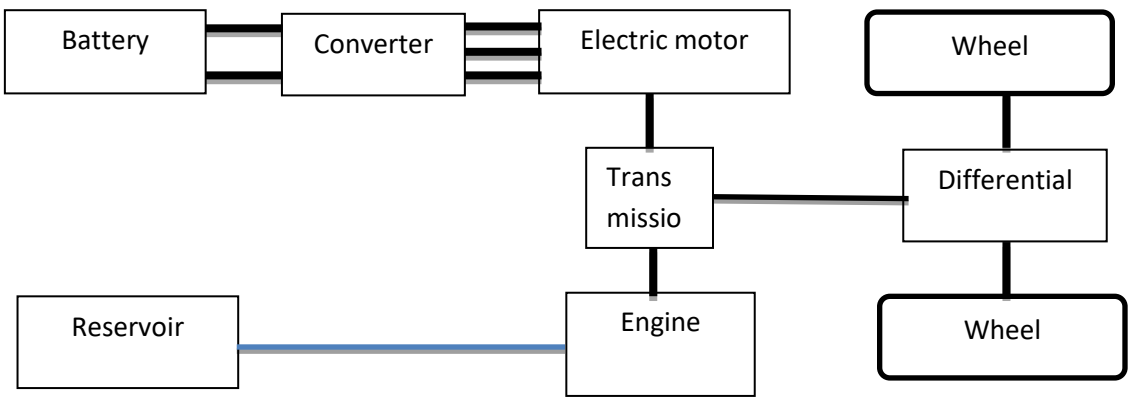
	e)	**Describe toroidal combustion chamber with neat sketch.**	**4**
		Answer: (*Sketch: 2 mark, Description: 2 Mark*) **Diagram:**  fig. toroidal combustion chamber **Description :** **Toroidal Chamber:** This is a Direct injection open type combustion chambers used in C I Engine. The idea behind this shape is to provide a powerful squish along with the air movement, similar to that of the familiar smoke ring, within the toroidal chamber. Due to powerful squish the mask needed on inlet valve is small and there is better utilisation of oxygen. The cone angle of spray for this type of chamber is 150° to 160°.	2 2
	f)	**Draw a neat graph to indicate effect of speed on ignition delay in a C.I. Engine**	**4**
		Answer:  **Fig. Effect of speed on ignition delay in C.I. Engine**	4

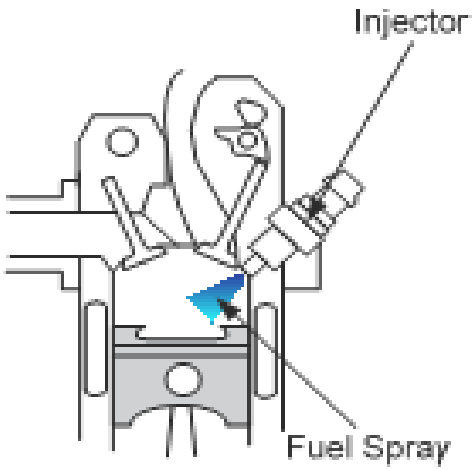
3		**Attempt any FOUR of the following:**	**16**
	a)	**With a neat sketch describe the construction of PFI system.**	**4**
		Answer : (*Sketch: any one 2 mark, Description: 2 Mark*) In the PFI SYSTEM (port fuel injection), every cylinder is having separate injectors, which are placed in the intake port just before the valve opening. The throttle valve regulates the air quantity and air/fuel mixture is prepared before valve opening for combustion. This system consists of 1. Air supply system - air cleaner, air flow meter, throttle valve, air intake chamber, intake manifold runner, and intake valve. 2. Fuel supply system - fuel tank, fuel pump, fuel filter, fuel delivery pipe (fuel rail), top feed fuel injector, fuel pressure regulator, and fuel return pipe 3. Electronic control module or unit. Various sensors monitor all important engines operating data, which are then used to calculate the triggering signals for the injectors and other system actuators.   *Fig. 10.3 Port Injection* **OR** 	2 2

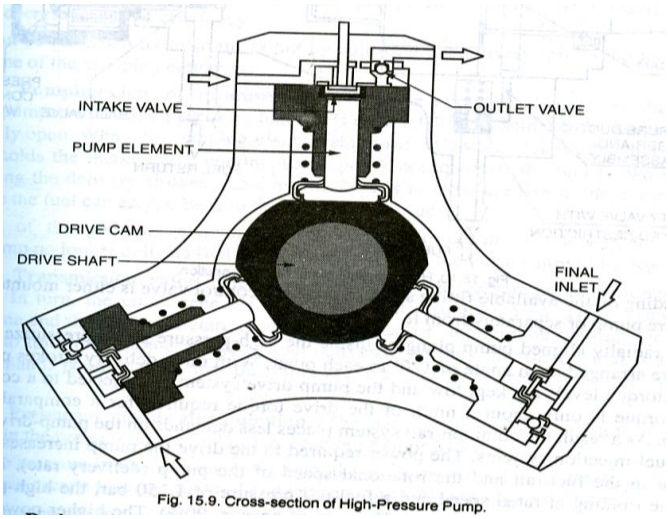
	b)	**Draw a neat labeled diagram of fuel injector used in MPFI system.**	**4**
		Answer: (*Diagram 2 mark, labelling: 1 Mark*)  TOP FEED FUEL INJECTOR	4
	c)	**Draw a neat block diagram indicating the inputs and outputs of ECM.**	**4**
		Answer:(*Credit should be given to an equivalent sketch)*  	4

		OR  	
	d)	**State any four advantages of CRDI system over conventional fuel injection system**	**4**
		Answer: *(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 NOx 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.	4
	e)	**What is a glow Plug? Why and where it is used?**	**4**
		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.	1

		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. **Applications** – 1.Diesel engines 2. Aircraft Engines	2 1
	f)	**State the function of high pressure pump and high pressure accumulator used in CRDI system.**	**4**
		Answer: **High pressure Fuel Pump:** To receive pre- pressurized fuel from the fuel feed pump and supply desired high pressure fuel to the accumulator. **High pressure accumulator:** The function of high pressure accumulator is to 1.Accumulate fuel supplied by the high pressure fuel pump 2. Supply fuel through the high pressure lines to the individual injectors. 3. It also dampens the fuel pressure fluctuation caused by high pressure pulses.	2 2
4	**A)**	**Attempt any THREE of the following:**	**12**
	a)	**State the need of Electric car. List two advantages and limitations of the same.**	**4**
		Answer: *(Need 1 mark, Disadvantage 1 1/2 marks, Limitations 1 1/2 marks)* **Need of Electric car:** To reduce global warming, smog-forming, and toxic pollution from vehicles (zero emissions) and due to shortage of conventional fuel **Advantages:** *(Any two points)* 1. Rapid acceleration 2. Noise free operation 3. No exhaust fumes 4. High reliability 5. Easy maintenance 6. Regenerating braking 7. No loss power in idling. 8. Easy to drive **Limitations:** *(Any two points)* 1. Need to charge the batteries. 3. More expensive to replace the batteries. 3. Not suitable for heavy vehicles	1 *1 1/2*

		4. Life of batteries quite short 5. Limited power 6. The top speed is quite low	1 1/2
	b)	**Draw a labelled block diagram of parallel type hybrid vehicle.**	**4**
		Answer: (*block diagram with labels – 4 marks Credit should be given to an equivalent diagram*) **Parallel type hybrid vehicle**  **OR**  **Block diagram of Parallel type Hybrid vehicle.**	4
	c)	**State with reasons whether alcohol can be used as an alternative fuel for C.I engine.**	**4**
		Answer: Alcohol is not a suitable fuel for C.I. engines for the following reasons. 1. The Cetane number of alcohol fuels is very low (0 to 8), which prevents their ignition by compression 2. Alcohol fuels have low lubricating qualities – causing trouble in the ignition pumps and nozzles.	

		3. There are material problems caused by harsh reaction of methanol towards various plastics and metals. Because of very low ignition quality (Cetane number), alcohols cannot be used alone as fuels for the diesel engines without some in- cylinder assistance like, -- Spark plug, glow plug or other heated surface. 4. To increase the Cetane number (ignition quality) of alcohol, chemical ignition accelerators (usually organic nitrates) may be added to alcohol. 5 % to 20 % additives are required for knock free operation. 5. Another method of using alcohol in diesel engines is by dual injection. The alcohol can be injected into the cylinder by a second high pressure system or into the inlet manifold by a low pressure system; in either case the charge of diesel fuel is used to initiate the combustion process.	4
	d)	**Describe the concept of GDI with neat sketch.**	**4**
		Answer:*(Discription 2 marks, sketch 2 marks)* **Gasoline Direct Injection (GDI)**, also known as Petrol Direct Injection. This system is employed in modern two-stroke and four-stroke gasoline engines. The gasoline is highly pressurized, and injected via a common rail fuel line directly into the combustion chamber of each cylinder, Directly injecting fuel into the combustion chamber requires high pressure injection. The GDI engines operate on full air intake; there is no air throttle plate. Engine speed is controlled by the engine control unit. In this only the combustion air flows through open intake valve on the induction stroke. The engine management system continually chooses among three combustion modes: ultra-lean burn, stoichiometric, and full power output. Each mode is characterized by the air-fuel ratio. The stoichiometric air-fuel ratio for gasoline is 14.7:1 by weight, but ultra-lean mode can involve ratios as high as 65:1 (or even higher in some engines, for very limited periods).These mixtures are much leaner than in a conventional engine and reduce fuel consumption considerably.  	2 2

4	B)	**Attempt any ONE of the following:**	06
	a)	**With the help of a neat sketch describe construction and working of high pressure pump used in CRDI system.**	6
		Answer: *(Construction 2 marks, working 2 marks sketch 2 marks)* **Constriction:** The radial –piston type high pressure pump is used. It consists of three radially pump plungers place at an angle of 120 degree to each other. There will be three delivery strokes per revolution. The engine power is taken to rotated the driving shaft to which cam is attached. The pump is lubricated by the fuel and can absorb up to 3.8kW. The low pressure pump supplies the filtered fuel to inlet of high pressure pump. **Working:** **Downward motion of plunger**: The safety valve at the inlet opens if the pre-supply pressure of fuel exceeds 1.5 bars and fuel comes and fills the chamber till the plunger moves up to BDC. **Upward motion of plunger:** - the upward motion of plunger closes the safety valve and increases the fuel pressure, this rise in pressure if it is more than the desired pressure then outlet (delivery) valve opens and pressurized fuel goes to common rail. Once the plunger reaches the TDC position then pressure falls and outlet valve closes. **Element shut-off valve –**The pump flow can be varied with engine load; individual pistons of the pump are able to be shut down by using a solenoid to hold the intake valve of that piston open. **Delivery rate –** The delivery rate of pressurized fuel during idling or part load condition is very high but this can be reduced with help of pressure control valve.  Fig. 15.9. Cross-section of High-Pressure Pump. **OR** **Constriction:** The high pressure fuel pump consist of a SCV, a fuel inlet, an outlet, a fuel return, a pressure regulator, fuel temperature sensor etc. The pump consists of an inner cam which is driven by the engine. Inside the inner cam there are two sets of opposing plungers. The tip of the plunger comes in contact with the inner surface of the cam.	2 2 2 2

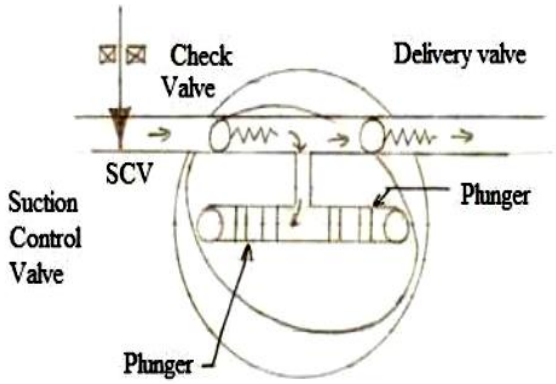


Figure: Sectional view of High Pressure Fuel pump in CRDI system

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Working:

1.The fuel inlet to the pump is controlled by the SCV (suction control valve) through the EDC

2. The rotation of the inner cam pushes the plunger inwards, so that it can pump the fuel.

3. Plunger outward movement is caused by the pressure of fuel feed pump. Fuel enters the pumping element chamber (intake stroke)

4. At BDC the check valve closes

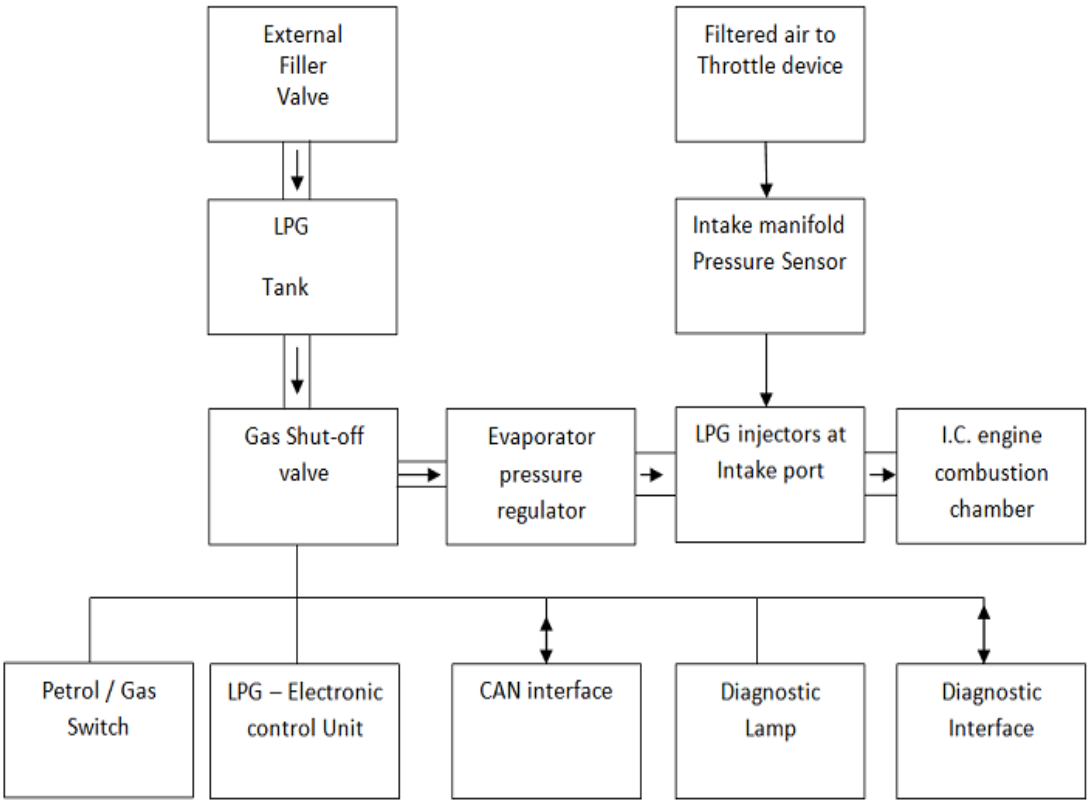
5. The fuel in the chamber is pressurized by the plungers moving inward.

6. The delivery valve opens and the fuel passes to the common rail.

7. A constant pressure of about 1400 to 1600 bar is maintained in the common rail.

2

	b)	**Draw a labelled block diagram of LPG conversion Kit. Describe it's working.**	**06**
		Answer: (*Credit should be given to equivalent explanation & Figure*) The LPG conversion kit contains a duel fuel conversion system which comes with the following components – 1. Tank, which contains the highly pressurized LPG in liquid form, comes in capacities of 30 to 100 ltrs. 2. The multivalve which controls and checks the filling of the tank comes with a 80% stop-fill safety feature. That's means the valve closes not allowing further filling when 80% of the tank is filled. 3. A device which automatically shuts of the tank and the fuel supply in the event of a ruptured line. 4.LPG solenoid valve 5.Gasoline solenoid valve 6.Electronic control module which controls of the flow of LPG in fuel injection systems 7.LPG / Petrol switch, which enables the driver to choose which fuel he wishes to use 8.Pressure regulator Mixer / gas injection which flows the LPG into the combustion chamber	3



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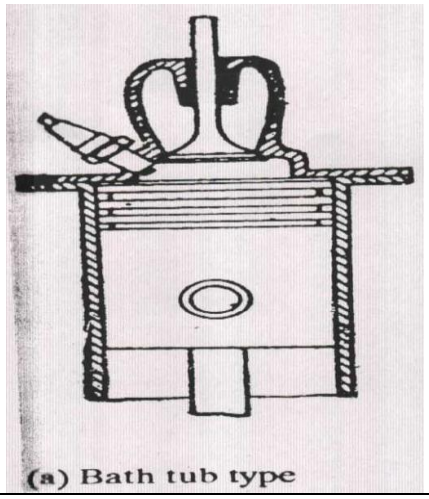
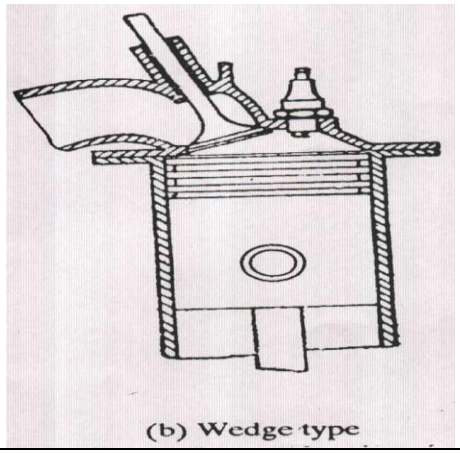
5		**Attempt any TWO of the following:**	**16**
	a)	**State four advantages of 'I'-head combustion chamber. Draw bath tub type and wedge type combustion chambers.**	**8**
		Answer: (*4 Advantages 4 marks, sketch of each combustion chamber 2 marks*) **Advantages:** 1. Lower pumping losses and higher volumetric 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.	4





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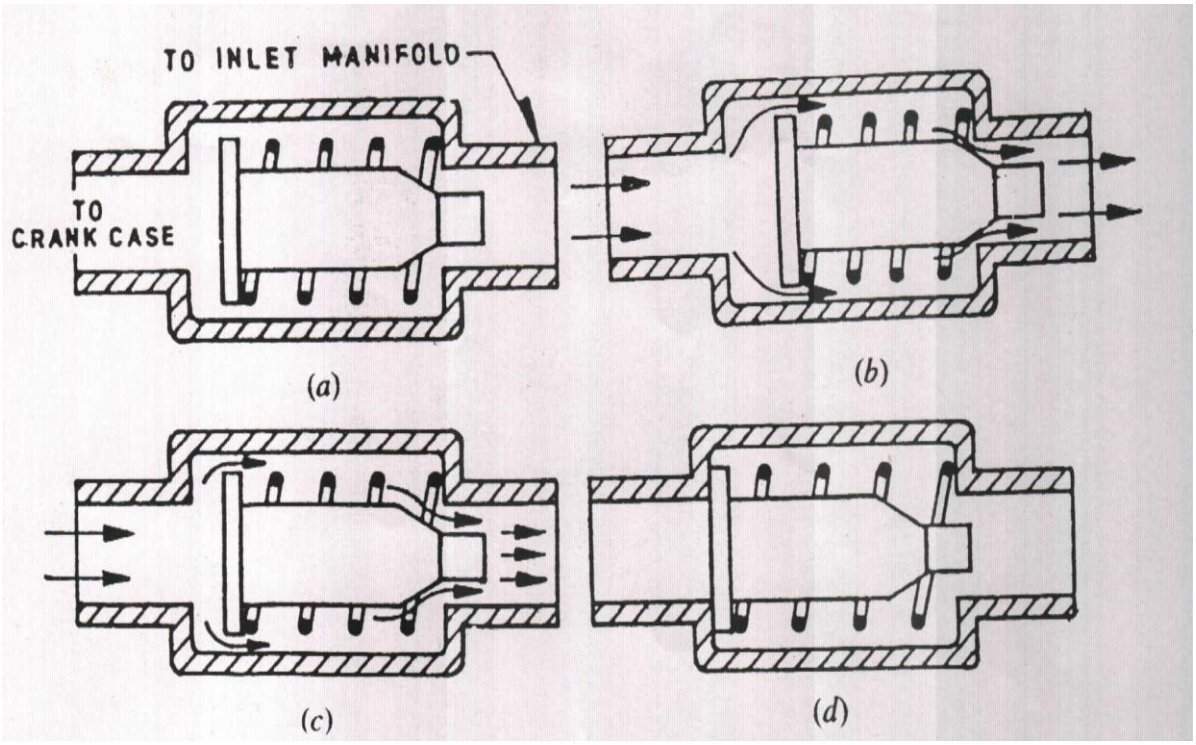
	b)	**Describe with sketch operation of PCV valve under different operating conditions to control emissions.**	**8**
		Answer: *(Description of each condition 1 mark , Figure: 1 mark for each case)* **PCV Valve:** It consists of a spring loaded tapered valve for flow control. The crankcase pressure and manifold vacuum act together to close the valve where as the spring pressure tends to keep it open.(Fig a) **At idle and low speed**: At idle and low speed, crank case emissions are very less due to lower cylinder pressure and manifold vacuum is high. Therefore only a small flow through PCV would be sufficient to keep the crank case clean. High manifold vacuum at idle and low speed would pull the valve to right to maintain the small flow.(Fig b) **At normal Speed:** Blow by increases and manifold vacuum decreases due to which valve moves to left increasing the flow **At high speed or Heavy loads:** No manifold vacuum acting on the valve, valve opens to maximum, increasing the flow to maximum capacity. (Fig c) **In case of backfire:** During cranking, high pressure will be produced in to the intake manifold which causes valve to back seat sealing the inlet and crankcase is protected from the back fire.(Fig d)  **Figure : (a) PCV valve construction (b)Operation at idle and low speed** **(c)High speed/Load operation (d)Preventing backfire during cranking**	4 4

	c)	**State four possible sources of atmospheric pollution from I. C. engine. Describe any two sources in detail**	**8**
		Answer: (*Each Source 1 mark, description of any two sources 4 marks*) **Sources of atmospheric pollution from I. C. engine** 1. The Fuel tank. 2. The Carburetor. 3. The Crankcase. 4. The Exhaust pipe. **1. Fuel tank losses:** These losses are due to displacement of vapour during filling of petrol tank or by vaporization of fuel in the tank forcing a vapour through breather vent to the atmosphere. At low temperature fuel tank breathes in air and at higher temperature it breathes out air loaded with petrol vapour. These losses occur due to increase in temperature during vehicle operation causing increase in vapour pressure. **2. Carburetor losses:** These losses results from a) External venting of float bowl relieving from the internal pressure as carburetor heat. b) Hot soak- These are the losses which occurs after the engine has been stopped. These are due to evaporation of petrol stored in bowl. Losses are through vent pipe or air cleaner. Most of the losses occurs due to direct boiling of fuel in carburetor bowl during hot soak. Temperature rises from 15 - 45 deg C above ambient. The bowl volume and maximum bowl temperature both affect evaporative losses from the carburetor. **3. Crankcase losses:** The crank blow by is the phenomenon of leakage past the piston and the Piston rings from the cylinder to the crankcase. The blow by emissions is about 20% of total HC emission from the engine. Blow by increases to about 30% if the rings are worn.Air fuel mixture trapped in the top land clearance and behind the top ring is unable to burn due to wall quenching effect. Cylinder forces these quenched gas past the piston ring and into crankcase along with some burnt gases. 85% carbureted mixture in the form of HC is present in Blow by. **4. Exhaust losses:** For several reasons combustion is incomplete and hence we also get Co, a deadly poisonous gas and unburnt hydrocarbons (UBHC) in exhaust. Hydrocarbon play an active part in the formation of smog. At temperatures higher than 1100deg C nitrogen react with oxygen to form various oxides of nitrogen. Some of the oxides of nitrogen are very toxic and harmful.	4 4
6		**Attempt any FOUR of the following:**	**16**
	a)	**How VGT is beneficial over conventional turbocharger?**	**4**
		Answer: *(For each benefit 1 mark)* **Advantages:** 1. Reduced turbo- lag time. 2. Increased efficiency of engine/ lower fuel consumption. 3. Higher rated power output. 4. Enhanced low speed power. 5. Lower engine emissions. 6. Power output of VGT is higher even at lower speed than conventional turbocharger.	4

	b)	**Describe any two methods used for improving the exhaust emission under the engine design modification approach.**	**4**
		Answer : *(Description of each method 2 marks, Description of any two methods 4 marks)* **Methods used for improving the exhaust emission under the engine design modification are** 1. **Use of leaner air-fuel ratios:** The carburetor may be modified to provide relatively lean air fuel mixtures during idling and cruise operation. With this modification, idle speed needs to be increased to prevent stalling and rough idle. Fuel distribution is improved by better manifold design, Inlet air heating, raising of coolant temperature and use of electronic fuel injection system. 2. **Retarding Ignition timing:** The controls are designed to retard the spark timing at idle and providing normal spark advance during acceleration and cruising. Retarding spark reduces $NO_{X.}$ Emission. It also reduces HC emission. 3. **Modification of combustion chamber:** Modification in combustion chamber is attempted to avoid flame quenching zones, resulting in HC emission. This includes reducing surface to volume ratio, reduced squish area, reduced deal space around piston ring and reduced distance of the top piston ring from the top of the piston. 4. **Lower compression ratio:** The lower compression ratio reduces the quenching effect by reducing quenching area reducing HC. It also reduces $NO_{X.}$ Emission. Reducing compression ratio results in some loss of power and fuel economy. 5. **Reduced valve overlap:** Increased valve overlap allows some mixture to escape directly to increase emission level. This can be controlled by reducing valve overlap. 6. **Alterations in induction system:** The supply of designed air fuel ratio to all cylinders under all operating conditions can be affected by alterations in induction. This includes inlet air heating, use of carburetor with closer tolerances and using special type of carburetors. This also includes fuel injection in manifold.	4
	c)	**Describe the working of EGR with neat sketch.**	**4**
		Answer: *(Description of working 2 marks, Sketch 2 marks)* The EGR system is used to reduce the amount of NOx in the exhaust. NOx 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 NOx 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 NOx 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	2

2

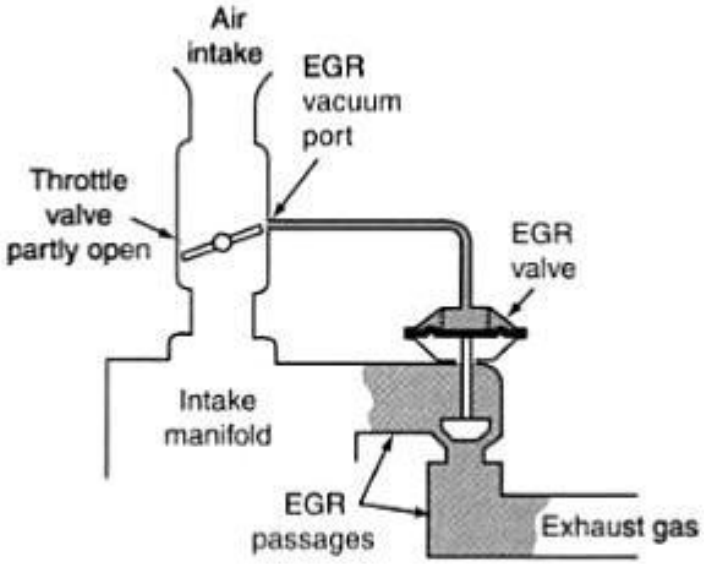
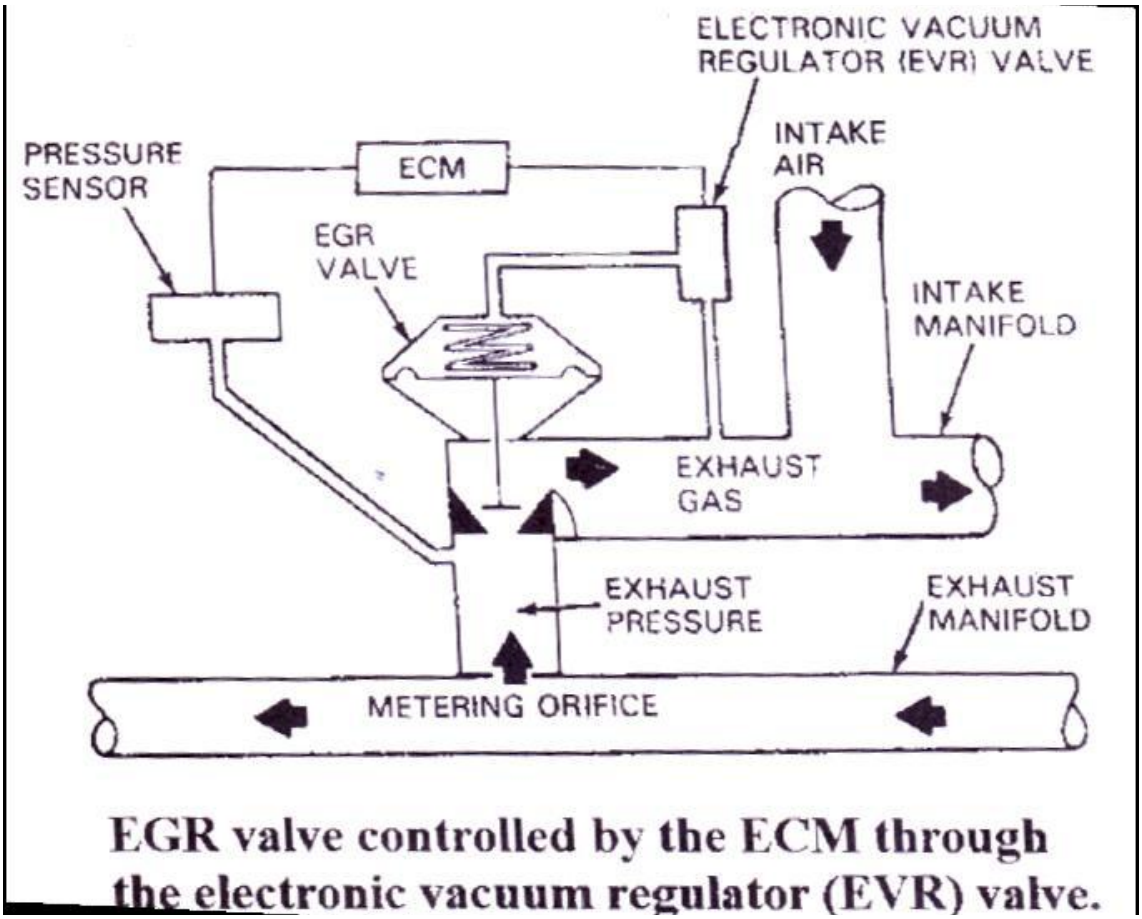


Fig: Exhaust gas recirculation system controls the amount of exhaust flowing back into the intake manifold

OR



EGR valve controlled by the ECM through the electronic vacuum regulator (EVR) valve.

	d)	**Define smoke? State two methods to control diesel smoke.**	**4**
		Answer: *(Definition 2 marks, Methods 2 marks)* **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.	2 2
	e)	**State Bharat Stage IV norms for cars in India.**	**4**
		Answer: *Note: Credit should be given to information in sentence format, mentioning Bharat stage norms being equivalent to corresponding Euro norms. Two / three rows need to be appearing for BS emission norms containing permissible levels of pollutants*	4

Table 1: Indian Emission Standards (4-Wheel Vehicles)

Standard	Reference	Date	Region
India 2000	Euro 1	2000	Nationwide
Bharat Stage II	Euro 2	2001	NCR*, Mumbai, Kolkata, Chennai
		2003.04	NCR*, 13 Cities†
		2005.04	Nationwide
Bharat Stage III	Euro 3	2005.04	NCR*, 13 Cities†
		2010.04	Nationwide
Bharat Stage IV	Euro 4	2010.04	NCR*, 13 Cities†
Bharat Stage V	Euro 5	2020 (proposed)	Entire country

* National Capital Region (Delhi)

† Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, Jamshedpur and Agra

The above standards apply to all new 4-wheel vehicles sold and registered in the respective regions.

OR

Table 2 Emission Standards for a Diesel Car (GVW ≤ 2500 kg)

g/km

Year	Reference	CO	HC	$HC+NO_x$	NO_x	PM
1992	–	17.3–32.6	2.7–3.7	–	–	–
1996	–	5.0–9.0	–	2.0–4.0	–	–
2000	Euro 1	2.72–6.90	–	0.97–1.70	0.14–0.25	–
2005†	Euro 2	1.0–1.5	–	0.7–1.2	0.08–0.17	–
2010†	Euro III	0.64		0.56	0.50	0.05
2010‡	Euro 4	0.50		0.30	0.25	0.025

† earlier introduction in selected regions, see Table 1

‡ only in selected regions, see Table 1

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