SUMMER-2019 EXAMINATION

Subject Name: Advance Automobile Engine **Model Answer** 17523

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 FIVE of the following:**	20
	a)	**State four properties of SI engine fuel.**	4
		Answer: Desirable properties of S.I. engine fuel are as follows: *(four properties, one mark each)* 1. It should mix readily with air and provide uniform manifold distribution. That is, it should easily vaporize. 2. It must be knock resistant. 3. It should not pre-ignite easily. 4. It should be easy to handle. That is, it should have sufficiently high flash point and fire point. 5. It must burn clean and produce no corrosion on engine parts. 6. It must have a high calorific value 7. It should not form gum and varnish. **OR** 1. Volatility2. Knock Resistivity 3. Sulphur Content 4. Gum Content	4
	b)	**Draw P-Ø diagram showing stages of combustion in SI engine.**	4
		Answer: Stages of combustion in SI engines **Stage I**: **Ignition Lag or Preparation Phase:** The time elapsed between the fuel injection into the combustion chamber and starting of combustion. It is the growth and development of a semi propagating nucleus of flame. It is a chemical process which depends on-nature of fuel, temperature & pressure, proportion of exhaust gas, rate of burning and temperature. **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	2

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.

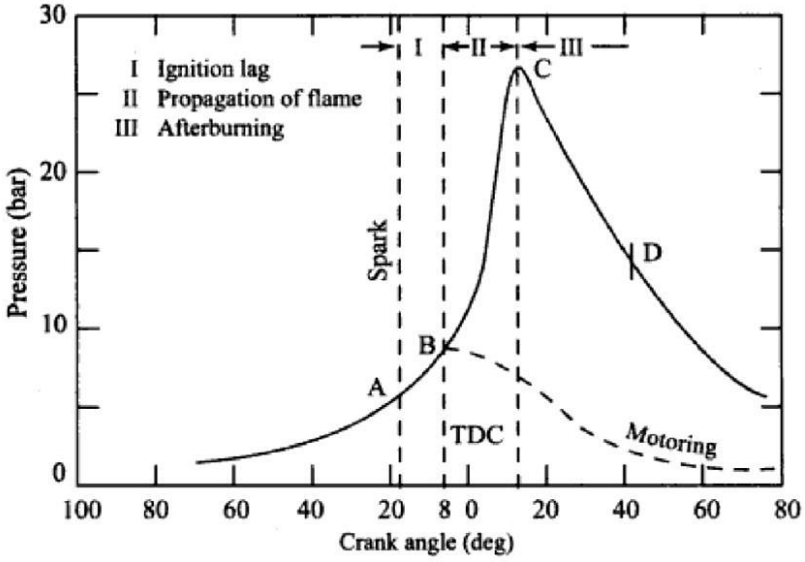


Figure: P- Θ diagram (Stages of combustion in SI engine) **2**

c) State the methods of improving fuel economy. **4**

Answer: *(Any four :-1 mark for each)*

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). **4**

d) Compare TBI and PFI system. **4**

Answer: Comparison of TBI system with PFI system *(Any 4 points 1 mark each)*

Sr	Throttle Body Injection(TBI)	Port Fuel Injection(PFI)
1	Fuel is injected into the center of the throttle body.	Fuel is injected into the port.
2	TBI uses bottom feed injector	PFI uses top feed injector
3	Fuel injector needs to be flushed continuously to prevent formation of air bubble.	Fuel injector need not be flushed

4

4	1 or 2 Fuel injectors are used.	Fuel injectors are equal to the number of cylinders
5	TBI is comparatively low pressure injection (differential pressure = 0.7 to 1 bar)	PFI is comparatively high pressure injection (differential pressure = 2 to 3.5 bar)
6	Cheaper fuel pump is sufficient to generate the required low pressure.	Costly fuel pump is required to generate the required pressure
7	Mixture mal-distribution may occur.	All cylinders receive equal quantity and quality of air: fuel mixture
8	Less accurate fuel injection control gives moderate fuel economy.	More accurate fuel injection control is obtained. Therefore increased fuel economy is obtained
9	This is a cheap system	This is costly system.
10	Exhaust emission is above the permissible emission norms	Very low exhaust emission is achieved to meet the strict emission norms
11	Moderate throttle response as the fuel is injected at the throttle body and longer length of travel for fuel to enter the engine cylinder	Better throttle response as fuel is injected on hot back side of intake valve and shorter length of travel for fuel – to enter the engine cylinder
12	Lower power output due to lower volumetric efficiency caused by bulky injector body at the throttle body.	Higher power output due to low resistance at intake manifold and higher volumetric efficiency.

e) Explain the concept of VGT **4**

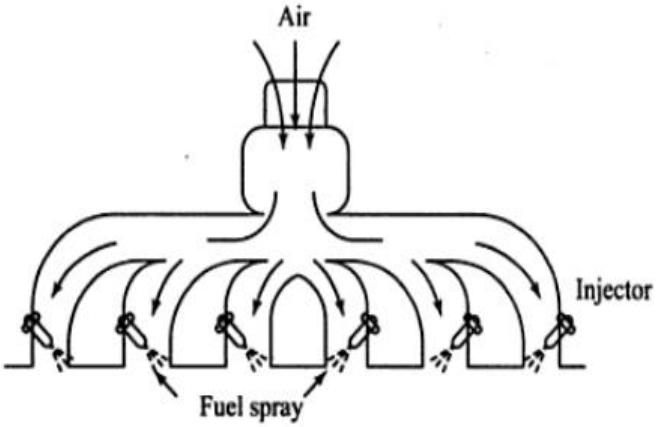
Answer:

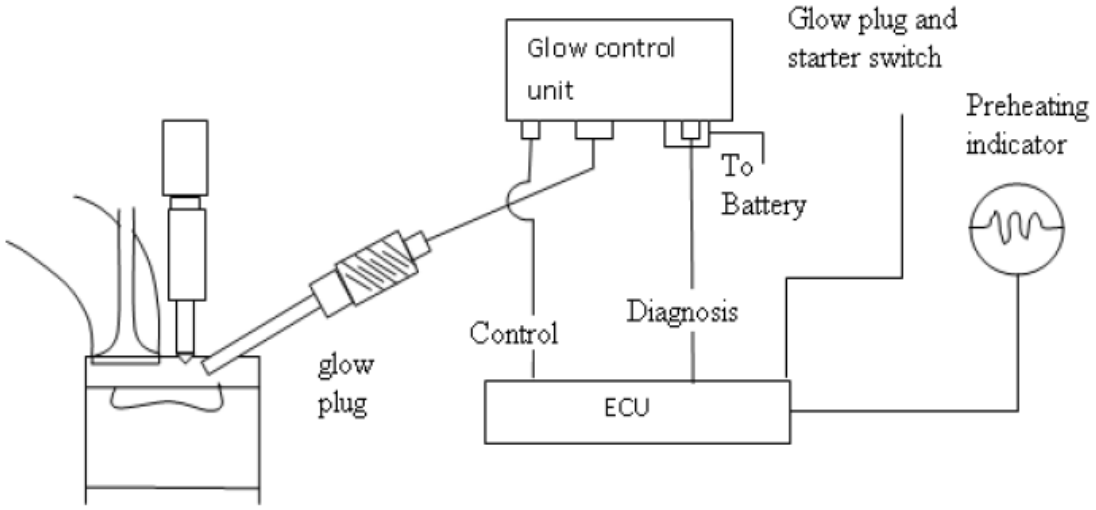
Variable geometry turbochargers usually designed to provide effective aspect called A/R Ratio) of the turbo to be altered as conditions change. This is done because optimum aspect ratio at low engine speeds is very different from that at high engine speeds. If the aspect ratio is too large, the turbo will fail to create boost at low speeds, if the aspect ratio is too small, the turbo will choke the engine at high speeds, leading to high exhaust manifold pressures, high pumping losses, and ultimately lower power output. By altering the geometry of the turbine housing as the engine accelerates, the turbo's aspect ratio can be maintained at its optimum. When the aspect ratio maintained at its optimum, the following benefits are obtained over conventional turbo-charging **4**

f) Describe four effects of detonation.

Answer: Four effects of detonation *(Any four 1 mark each)*

1. Noise and roughness: Mild knock is seldom audible and is not harmful. When intensity of knock increases a loud pulsating noise is produced due to development of a pressure wave. The presence of vibratory motion causes crankshaft vibrations and engines rough.
2. Mechanical damage: Due to rapid pressure waves, rate of wear is increased and piston head, cylinder head and valves may be pitted.
3. Carbon deposits: Detonation results in increased carbon deposits.
4. Increase in heat transfer: Temperature in detonating engine is higher as compared to non detonating engine and hence scoring away the protecting layer of inactive stagnant gas. So detonation increases the rate of heat transfer to combustion chamber walls. **4**
5. Decrease in power output and efficiency: Due to increase in the rate of heat transfer the power output is decreased.
6. Pre ignition: Detonation results in over heating of the sparking plug and combustion chamber wall and this overheating leads to ignite the charge before the passage of spark.

	g)	**State four advantages of CRDI system.**	
		Answer: Advantages of CRDI system *(Any four 1 mark each)* 1. Separation of pressure generation and injection allowing flexibility in controlling both the injection rates and timing of CRDI 2. In CRDI system, Fuel pressure does not depend on the engine speed and load conditions 3. In CRDI, High injection pressures (about 1500 bar) and good spray preparations are possible even at low engine speeds and loads. 4. Reduced noise. 5. Pollutants are reduced. 6. In CRDI system, Fuel pump operates with low drive torque. 7. Increased fuel efficiency. 8. More stability. **OR** 1. Deliver 25% more power and torque than the normal direct injection engine. 2. Lower levels of noise and vibration. 3. Lower emissions. 4. Lower fuel consumption. 5. Improved performance. 6. Improved drivability	**4**
2		**Attempt any <u>TWO</u> of the following:**	**16**
	a)	**Write neat sketch, describe MPFI system.**	**8**
		Answer: MPFI system In the port injection arrangement, the injectoe is placed on the side of the intake manifold near the intake port. The injector sprays gasoline into the air, inside the intake manifold. The gasoline mixes with the air in the intake manifold near the intake port. This mixture of gasoline and air then passes through the intake valve and enters into the cylinder. Every cylinder is provided with an injector in its intake manifold. If there are six cylinders, there will be six injectors as shown in figure.  	**4** **4**
	b)	**Draw the circuit diagram of glow plug and explain its operation.**	**8**
		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.	**4**
		 ECU Controlled Glow Plug System on D.I. Engine	**4**
	c)	**Explain the effects of engine variables on ignition lag and flame propagation.**	**8**
		Answer: *(Any four variables of each 1 mark each)* **Effect of engine variables on Ignition lag** **1) Fuel**- it is depend on chemical nature of fuel. The higher, the self-ignition temp of fuel, the longer will be the ignition lag. **2) Mixture Ratio**-The ignition lag is smallest for the mixture ratio which gives the maximum temperature this mixture ratio is somewhat richer than the stoichiometric ratio. **3) Initial pressure and temperature** –increasing the intake temp, pressure, compression ratio and retarding spark, all reduce the ignition lag. **4) Electrode gap**-It affects establishment of the nucleus of flame. If the gap is too small, quenching of the flame nucleus may occur & rang of fuel –air ratio for the development of a flame nucleus is reduced. **5) Compression ratio**-An increase in the compression ratio can reduce the ignition lag. **6) Turbulence**-Ignition lag is not much affected by turbulence intensity. Turbulence is directly proportional to engine speed. **Effects of engine variables of Flame propagation** **1) Fuel-Air ratio**-Maximum flame velocities occur when mixture strength is 10% of stoichiometric. Lean mixtures release less thermal energy resulting in lower flame temperature & flame speed. Very rich mixtures have incomplete combustion (Some carbon only burns to CO & not to CO2), which results in production of less thermal energy & hence flame speed is again low. **2) Compression ratio**-A higher compression ratio increases the pressure & temperature of the working mixture & decrease the concentration of residual gases. High pressures & temperature of the compressed mixture also speed up the flame propagation.	**4**

3) Intake temp & pressure-Increase in the intake temperature & pressure increases the flame speed.
4) Engine load-With increases in the engine load the cycle pressures increase. Hence the flame speed increases.
5) Turbulence-The flame speed is very low in non-turbulent mixtures. A turbulent motion of the mixture intensifies the processes of heat transfer & mixing of the burned & unburned portions in the flame front (diffusion). These two factors cause the velocity of turbulent flame to increase practically in proportion to the turbulence velocity. However, excessive turbulence is also undesirable. **4**
6) Engine speed - The higher the engine speed the greater the turbulence inside the cylinder. For this reason the flame speed increases almost linearly with engine speed. The crank angle required for the flame propagation, which is the main phase of combustion, will remain almost constant at all speed.
7) Engine size- Engine of similar design generally run at the same piston speed. This is achieved by smaller engine having larger RPM & larger engines having smaller RPM. Due to the same piston speed. The inlet velocity, the degree of turbulence & the flame speed are nearly same in similar engines regardless of the size. i.e. the number of crank degrees required for flame travel will be about the same irrespective of engine size, provided the engine are similar.

3 **Attempt any TWO of the following:** **16**

a) **Compare performance characteristics of SI and CI engines.** **8**

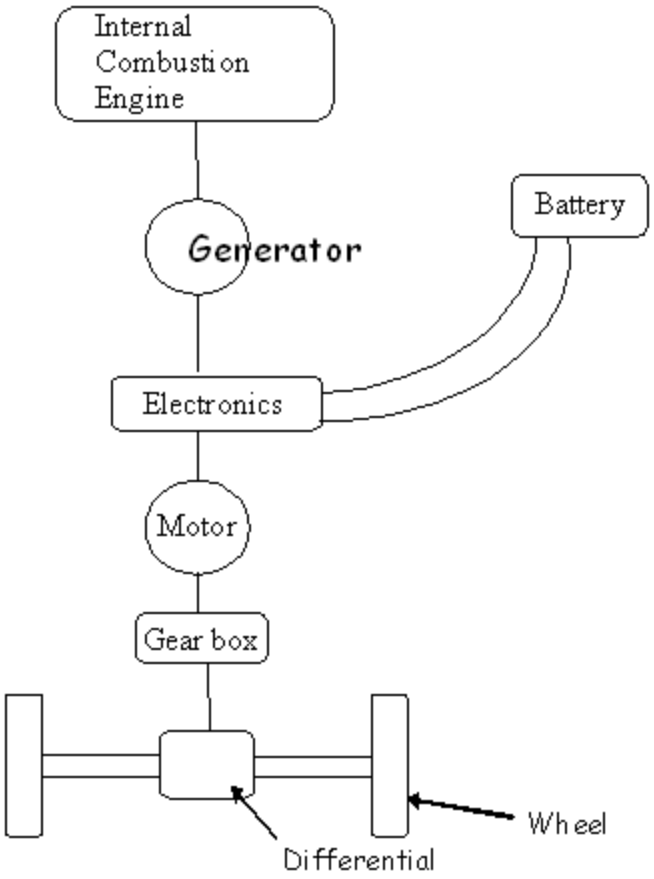
Answer: *(Any four points 2 mark each)* **8**

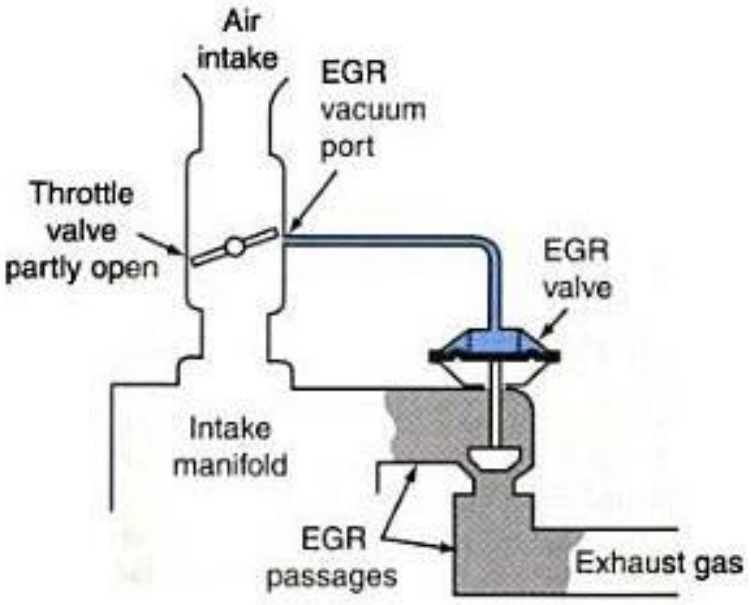
Variable/Parameter	SI Engine	CI Engine
Power output per unit weight	2.7 Kg/Kw	6.5 Kg/Kw
Power output per unit displacement	30 Kw/liter	15 Kw/liter
Acceleration	Not good	Best
Reliability	Low	High
Fuel economy	Moderate fuel economy at both full & part load. It has poor idling fuel economy	Better fuel economy at both full & part load, idling.
Fuel safety	More volatile so less safer	Less volatile so more safer

b) **What is hybrid vehicle? Explain working with the help of layout of a series hybrid vehicle.** **8**

Answer:
Hybrid Vehicle: A hybrid vehicle is one that uses two different methods to propel the vehicle. A hybrid electric vehicle, abbreviated HEV uses both an internal combustion engine and an electric motor to propel the vehicle. Most hybrid vehicles use a high-voltage battery pack and a combination electric motor and generator to help or assist a gasoline engine. The types of hybrid electric vehicles include series, parallel, and series-parallel designs. **2**

Series-Hybrid vehicle
In Series Hybrid vehicles, the Internal Combustion Engine (ICE) drives a generator, which charges the battery and supplies current to the electronically controlled motor. The electric motor propels the car. In this system, Internal Combustion Engine operates at constant speed with maximum efficiency, It causes low exhaust emissions. The vehicle is controlled electronically. **2**
The electric control simplifies the mechanical gears and the differential. Both Internal combustion

		engine and electric drive have to be rated to the maximum power. It has low overall system efficiency.  	**4**
	c)	**Explain the working of EGR with neat sketch.**	**8**
		Answer: **Exhaust Gas Recirculation System (EGR)** 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.	**4**



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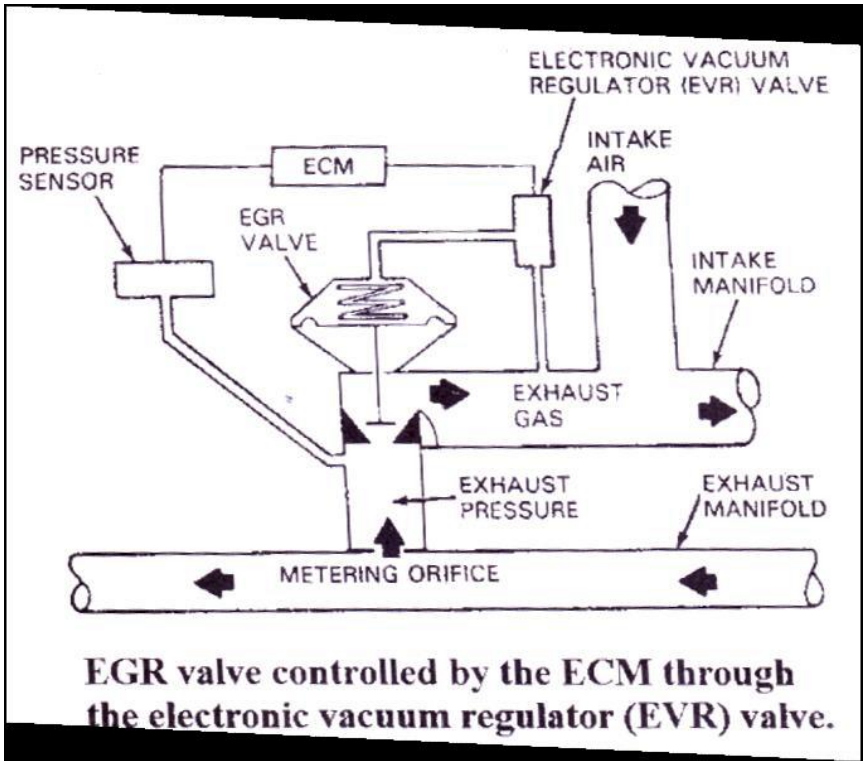
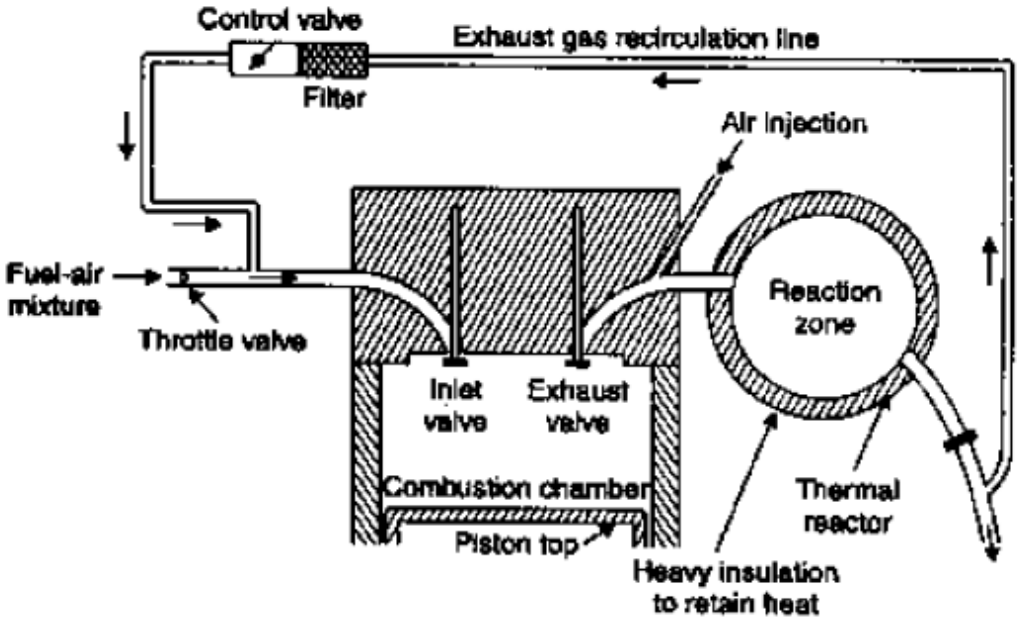


EGR valve controlled by the ECM through the electronic vacuum regulator (EVR) valve.

		OR  	
4		**Attempt any <u>FOUR</u> of the following:**	**16**
	a)	**State the advantages of DTSI.**	**4**
		Answer: *(Any four 1 mark each)* **Advantages of DTSI system** 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.	**4**
	b)	**Give any four sensors used in MPFI system.**	**4**
		Answer: *(Any four sensors 1 mark each)* **Four sensors used in MPFI system:** 1) Oxygen sensor 2) Mass air flow (MAF) sensor 3) Coolant temperature sensor 4) Throttle position sensor 5) Crank position sensor 6) Manifold absolute pressure sensor 7) Vehicle speed sensor 8) Cam Sensor 9) Knock Sensor 10) Cam Shaft Position Sensor 11) Intake air temperature sensor (IAT)	**4**
	c)	**State the pollutants from gasoline engines. And explain why it is formed?**	**4**
		Answer: **Pollutants from gasoline engine** 1. Carbon monoxide (CO) 2. Hydrocarbons (HC) 3. Oxides of nitrogen (NO) 4. Sulpher	**2**

Cause of pollutants formed

1. Pollutants are produced by the incomplete burning of the air-fuel mixture in the combustion chamber.
2. Due to no maintenance.
3. Crankcase blowby
4. Evaporative losses.

2

d) Draw the block diagram of electronic diesel control unit (EDC). **4**

Answer:

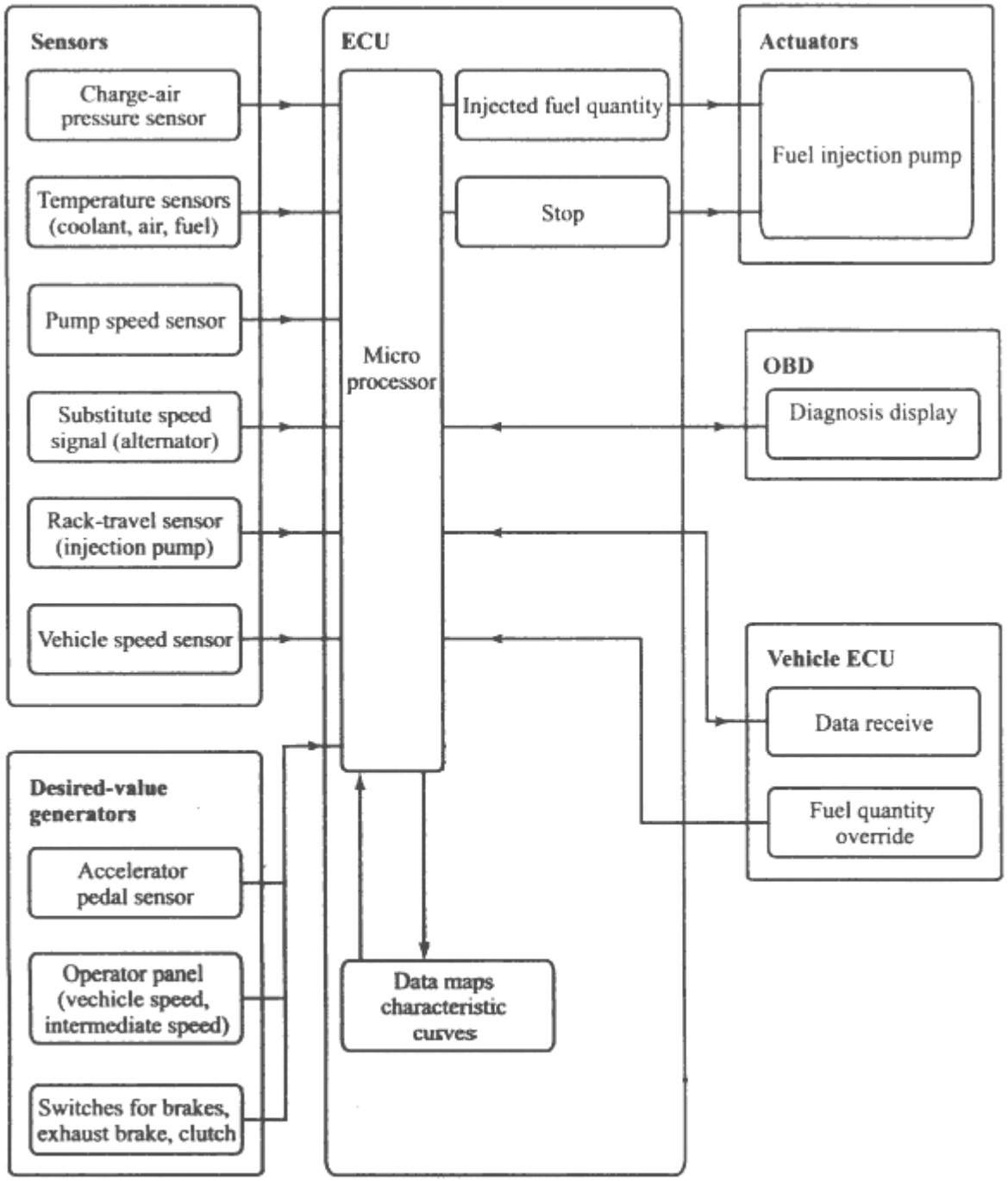
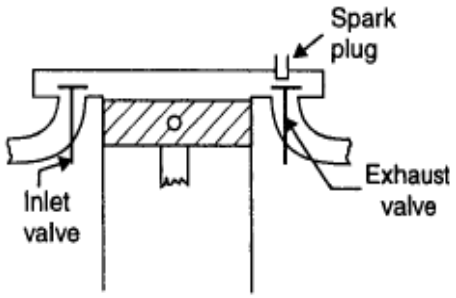


Fig: Block Diagram of EDC Unit

4

	e)	**Give advantages and disadvantages of LPG as a fuel for automobile engines.**	**4**
		Answer: *(Any two points each carry 1 mark)* **Advantages of LPG** 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. Residue and oil contamination is small as it burns cleanly: implies longer lubricating oil change period. 5. LPG is lead free – implies- less exhaust emission. 6. Life of spark plug is increased. 7. LPG has a higher octane rating than petrol. 8. It meets emission norms. 9. It can be transported easily to remote places by road and also by rail. 10. It results in increased engine life and smoother engine performance. 11. Crankcase oil dilution is small. So, oil replacement frequency is reduced. 12. Low engine deposits reduce the cost of maintenance. 13. Engine need not be modified. LPG kits are readily available (even for MPFI engines) and the kit cost is mostly affordable.	**2**
		Disadvantages of LPG 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.	**2**
	f)	**State the different types of SI engine combustion chambers. Draw a neat sketch of any one.**	**4**
		Answer: *(Types 2 Marks, Any one sketch 2 marks)* 1) T Head Type Combustion chambers 2) L Head Type Combustion chambers 3) F- Head combustion chamber 4) Over head valve or I head combustion chamber 5) Hemispherical combustion chamber 6) Bathtub combustion chamber 7) Wedge shaped combustion chamber. 1) T Head Type Combustion chambers	**2**



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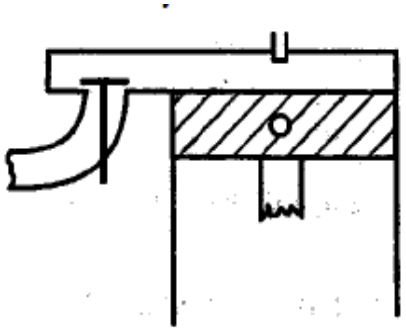
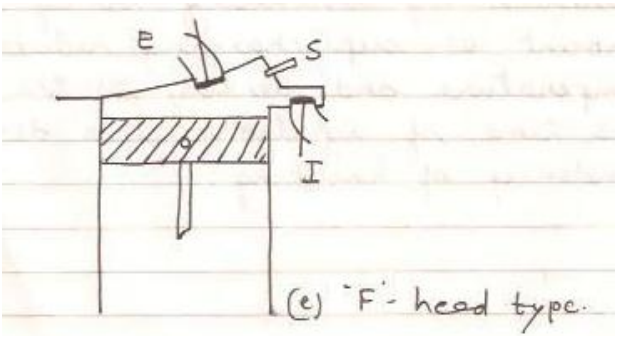
2) L Head Type Combustion chambers



3) F- Head combustion chamber



4) Over head valve or I head combustion chamber

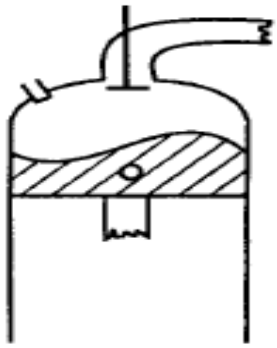
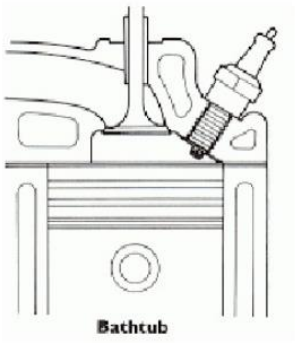
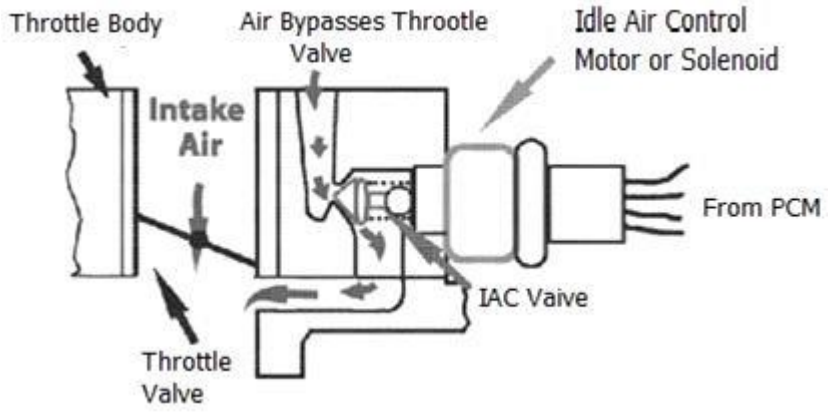


Fig. 5.22. *I*-head combustion chamber.

		  	
5.		**Attempt any <u>TWO</u> of the following:**	**16**
	a)	**State input and output control functions of ECM. Describe the idle speed control with sketch.**	**8**
		Answer: **Inputs and outputs of Electronic Control Module** The inputs of ECM 1. The Ignition (Engine Speed Sensor). 2. Temperature Sensor (Coolant Temperature). 3. Throttle Potentiometer (Intake Air Flow). 4. Throttle Switch (Idle and Overrun, WOT- Wide Open Throttle), Starter Switch. 5. Lambda (O2) Sensor. 6. Pressure Sensor (Manifold Pressure) and other sensors. The Outputs of ECM 1. Injection Volume Control. 2. Injection Timing Control. 3. Ignition Timing Control. 4. Evaporative Emission Control. 5. Turbocharger Boost Pressure Control (Diesel). 6. Engine / Vehicle Speed Control. 7. EGR Control. 8. Glow Plug Control (Diesel)	**2** **2**

Idle speed control system as output function of ECM



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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).

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.

2

OR

Idle speed control

While the engine is being started, or operated, the logic module of Electronic Control Module (ECM) will signal the **Stepper motor of Idle Speed Control (ISC) valve** to provide the easy starting without the operator having to touch the accelerator pedal.

1. When the engine is cold, the logic module will position the AIS motor to provide the correct cold fast idle speed. The ISC valve motor allows more air to flow past the motor plunger into the intake manifold to increase the idle speed. This air flow bypasses the throttle.
2. The ISC valve motor will provide the correct idle speed when the air conditioner is on and required air: fuel mixture when the engine is decelerating.
3. The injection time is extended to provide additional fuel for cold start and during the post-start and warm up phases. The idle speed is controlled by a stepper motor, which is signaled by ECM as a function of engine speed, load and engine temperature.
4. The stepper motor controls the idle passage size to change the amount of air entering the intake manifold. Thus it controls the effective air: fuel ratio.
5. Stepper Motor: It rotates a valve shaft either in or out. This in turn increases or decreases the clearance between the ISC (Idle Speed Control) valve and its seat, thereby regulating the amount of air allowed to pass through. The Idle speed control valve stepper motor allows 125 possible valve opening positions.

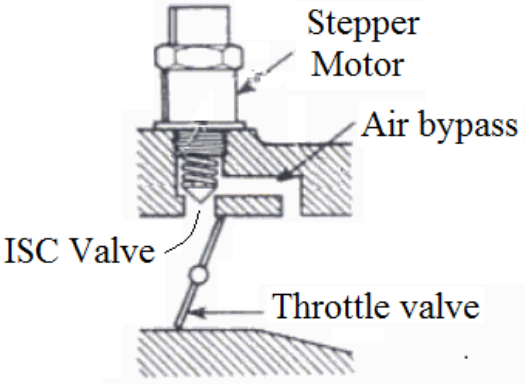


Figure: Idle Speed Control

b) Draw a block diagram of CRDI system and describe its working. **8**

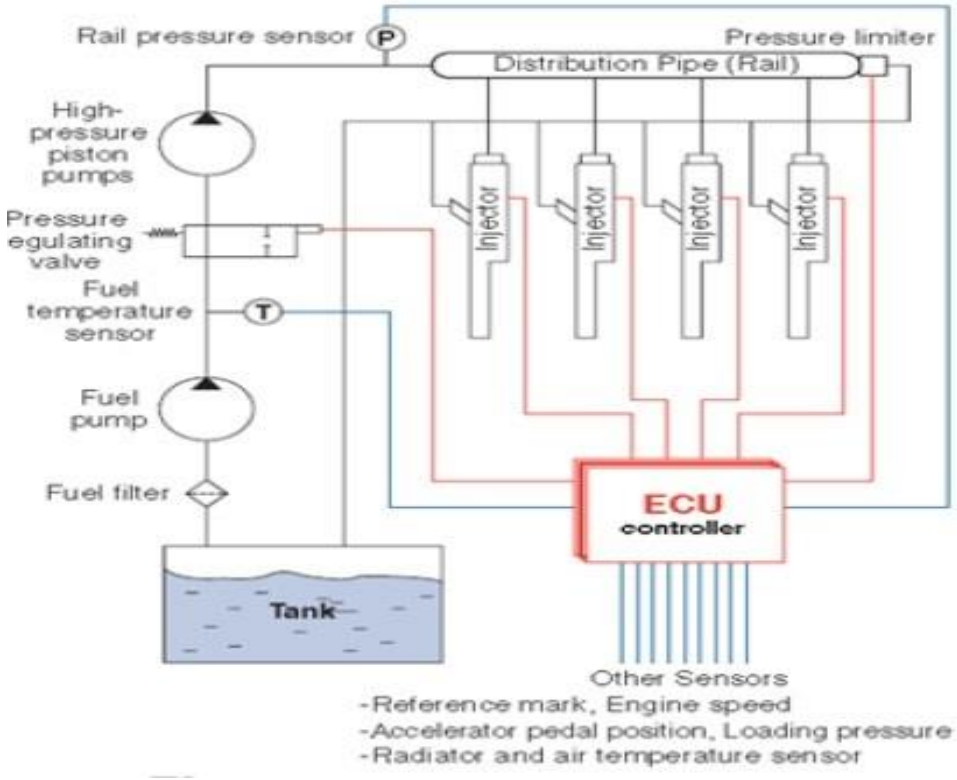
Answer: *(Working 4 marks, block diagram 4 marks)*

Working of CRDI system:

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.

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. **4**

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.



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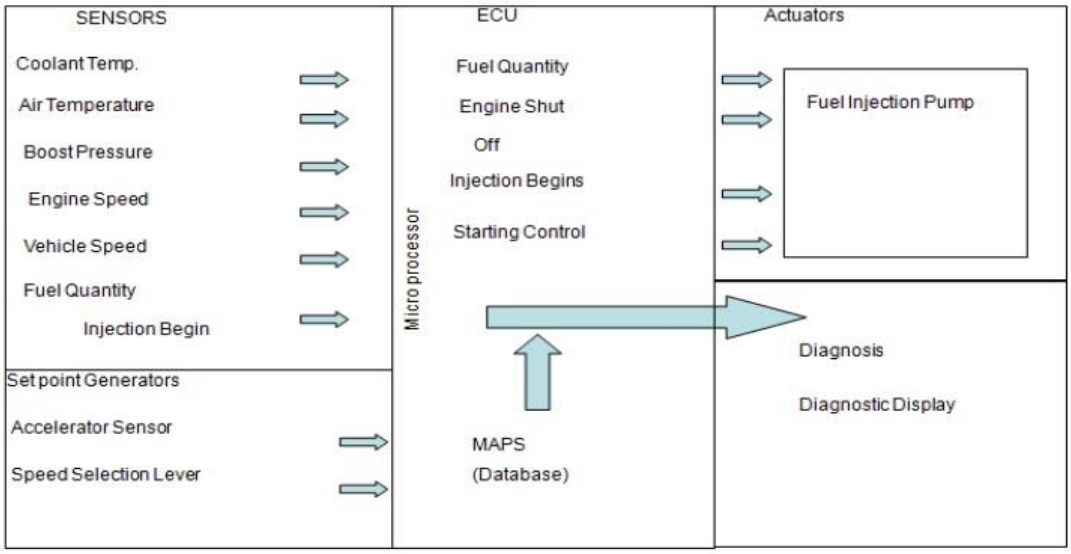


	c)	**i) State the drawbacks of carbureted (SI) engines on the basis of fuel distribution, emission, power output and fuel consumption.**	**4**
		Answer: Drawbacks of carburetted S.I. engine: *(Any Four points- 04 marks)* 1) Fuel distribution- Mal-distribution of charge. 2) Emission- More emissin 3) Power output- Less 4) Fuel consumption - More	**4**
		ii) Explain gasoline direct ignition system.	**4**
		Answer: 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.	**4**

6.		**Attempt any <u>FOUR</u> of the following:**	**16**
	a)	**What are the causes of diesel smoke?**	**4**
		Answer: *(Any four one mark each)* **Cause of diesel smoke:-** 1) Blue smoke is due to burning the droplets of lubricating oil in combustion chamber because of worn piston rings & cylinder liners. 2) White smoke is due to water come in combustion chamber because cracked water jacket. 3) Black smoke will come due to rich air fuel mixture because of malfunctioning of Fuel injection system 4) Gray (Blue+ white) smoke will come because of both failure i.e lubricating oil in combustion chamber because of worn piston rings & cylinder liners & water come in combustion chamber because cracked water jacket.	**4**
	b)	**State the four properties of CI engine fuels.**	**4**
		Answer: *(Any four one mark each)* **Properties of CI fuel:** *(*1) Volatility 2) Viscosity 3) Flash point 4) Fire point 5) Cetane number 6) Calorific value 7) Sulphur 8) Contamination 9) Cloud point 10) Pour point	**4**
	c)	**State Euro norms and Bharat stage norms for cars.**	**4**
		Answer: Bharat stage norms for the car *(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 and Euro emission norms containing permissible levels of pollutants)*	

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*, 11 cities†
		2005.04	Nationwide
Bharat Stage III	Euro 3	2005.04	NCR*, 11 cities†
		2010.04	Nationwide
Bharat Stage IV	Euro 4	2010.04	NCR*, 13 cities‡
		2015.07	Above plus 29 cities mainly in the states of Haryana, Uttar Pradesh, Rajasthan and Maharastra [3231]
		2015.10	North India plus bordering districts of Rajasthan (9 States) [3232]
		2016.04	Western India plus parts of South and East India (10 States and Territories) [3232]
		2017.04	Nationwide [3232]
Bharat Stage V	Euro 5	n/a [a]	
Bharat Stage VI	Euro 6	2020.04	Nationwide [3827]

* National Capital Region (Delhi)
† Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Secunderabad, Ahmedabad, Pune, Surat, Kanpur and Agra
‡ Above cities plus Solapur and Lucknow. The program was later expanded with the aim of including 50 additional cities by March 2015
[a] Initially proposed in 2015.11 [3297][3298] but removed from a 2016.02 proposal [3349] and final BS VI regulation [3827]

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

4

d) What is delay period? State the variables affecting delay period. **4**

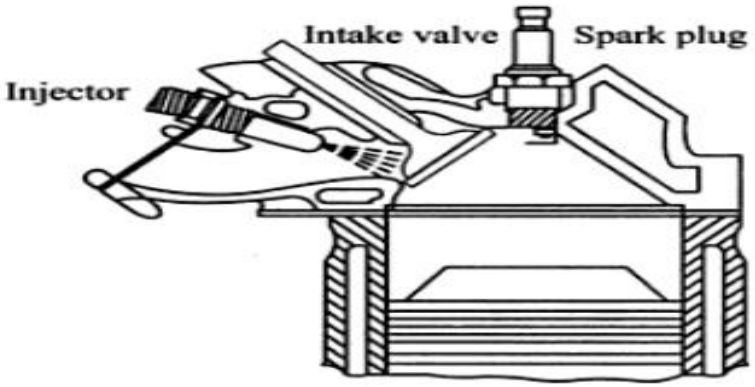
Answer:

Delay Period

The delay period is the time between the start of injection and start of combustion. **2**

Variables affecting delay period

1. Quality of fuel 2. Compression ratio 3. Injection pressure 4. Injection timing 5. Engine speed 6. Engine load 7. Intake temperature 8. Intake pressure or supercharging 9. Jacket water temperature **2**

	e)	**Explain PFI system with neat sketch.**	**4**
		Answer: PFI system In the port injection arrangement, the injector is placed on the side of the intake manifold near the intake port. The injector sprays gasoline into the air, inside the intake manifold. The gasoline mixes with the air in the intake manifold near the intake port. This mixture of gasoline and air then passes through the intake valve and enters into the cylinder.  	**2** **2**
	f)	**What is diesel knock? How it is controlled?**	**4**
		Answer: **Diesel knock** The knock phenomenon of C.I. engine depends upon delay period. If delay period is small then less amount of fuel is admitted into cylinder during ignition delay period. As it burns smoothly knocking do not occur. If the delay period is long, then more amount of fuel is accumulated in the combustion chamber during ignition delay period. When it actually burns, sudden pressure rise will cause the engine to vibrate, resulting in noise and this is said to be knocking. **Methods of controlling Diesel knocking:** 1) The delay period can also be reduced by reducing the degree of turbulence as it will reduce heat loss. However, it will increase the combustion period and thus reduce thermal efficiency. 2) The delay period can be reduced by adding chemical dopes, called ignition accelerators (ethyl-nitrate and amyl – nitrate). 3) Delay period can be reduced by multiple injections so that only small amount of fuel is injected at first (pilot injection).	**2** **2**