**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.

1. A) Attempt **any three** : **12**

a) Compare SI and CI Engines on the Basis of :
i) Thermal efficiency
ii) Compression ratio
iii) Power outputs per unit weight
iv) Applications — 4

**Answer: Comparison of SI and CI Engine-** *(1 mark each)* — 4

| **Parameter** | **S I Engine** | **C I ENGINE** |
|---|---|---|
| i)Thermal efficiency | Thermal efficiency less due to lower compression ratio. | Thermal efficiency more due to higher compression ratio. |
| ii) Compression Ratio | Compression ratio is low, about 10:1, limited by detonation. | Compression ratio is Higher, about 18:1 to 22:1. |
| iii)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. |
| iv) Applications | Sports Car, Passenger cars & Two wheeler engines | Heavy duty vehicle, commercial vehicle & Generator engines. |

b) State four drawbacks of carbureted SI engine — 4

**Answer: Drawbacks of carbureted SI engine:** *(Any 4 – 1 Mark Each)* — **4**

1) No altitude compensation.
2) Mal-distribution of charge.
3) Variation in air: fuel ratio.
4) Inaccurate metering of charge.
5) Does not meet emission norms.

6) No temperature compensation.
7) No compensation of Exhaust gas recirculation.
8) Fuel atomization depends upon velocity of air in the venture.
9) Wear and tear of parts results in poor efficiency.
10) Backfiring may take place.
11) Carburetor Icing may take place.

c) State four features of CRDI system. — 4

**Answer: Features of CRDI System:** *(Any 4 – 1 Mark Each)* — 4

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.

d) List four properties of hydrogen used as Fuel in I.C. engines. — 4

Answer: **Properties of hydrogen used as Fuel in I.C. engines:** *(Any 4 – 1 Mark Each)* — 4

| Sr. No | Particulars | Description |
|---|---|---|
| 1 | Color | Colourless |
| 2 | Odor | Hydrogen is an odorless gas |
| 3 | Density | The lowest of any chemical element, 0.09 grams per liter. |
| 4 | Flammability | Highly Flammable, a highly combustible diatomic gas |
| 5 | calorific value | 141790 KJ/Kg |
| 6 | octane rating: | Approximately 130 |
| 7 | Ignition temp | 560 °C |
| 8 | Boiling point | -253°C |
| 9 | Theoretical A/f ratio | 34:1 kg/kg |

| | |
|---|---|
| B) Attempt **any one :** | 6 |
| a) List the methods of fuel injection in SI engine and describe any one with neat sketch. | 6 |

**Answer:**

**Methods of fuel injection:**

1) Sequential fuel injection (SFI)
2) Grouped fuel injection
3) Simultaneous fuel injection
4) Continuous injection

2

**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.

2

**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.

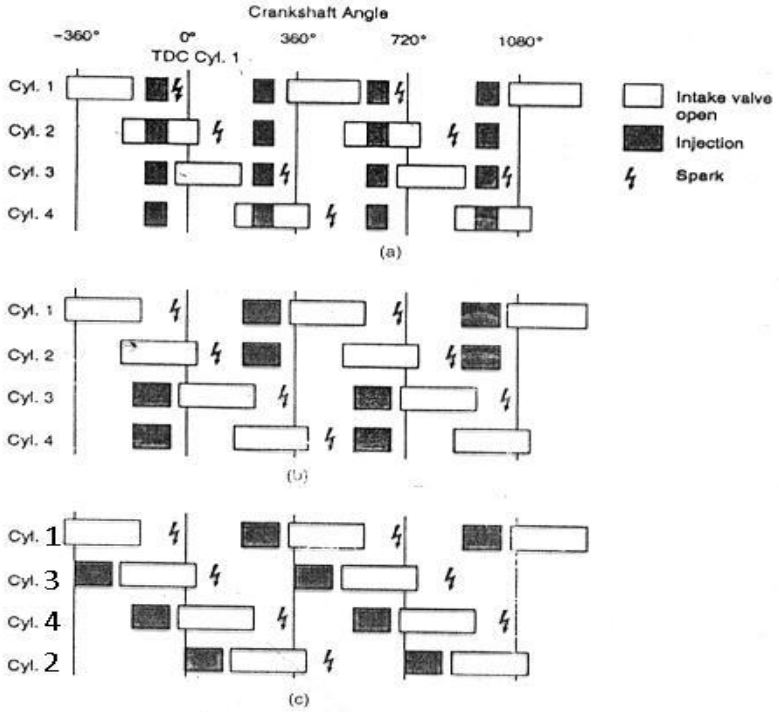



FIGURE Fuel injection strategies: (*a*) simultaneous injection, (*b*) group injection, and (*c*) sequential injection.

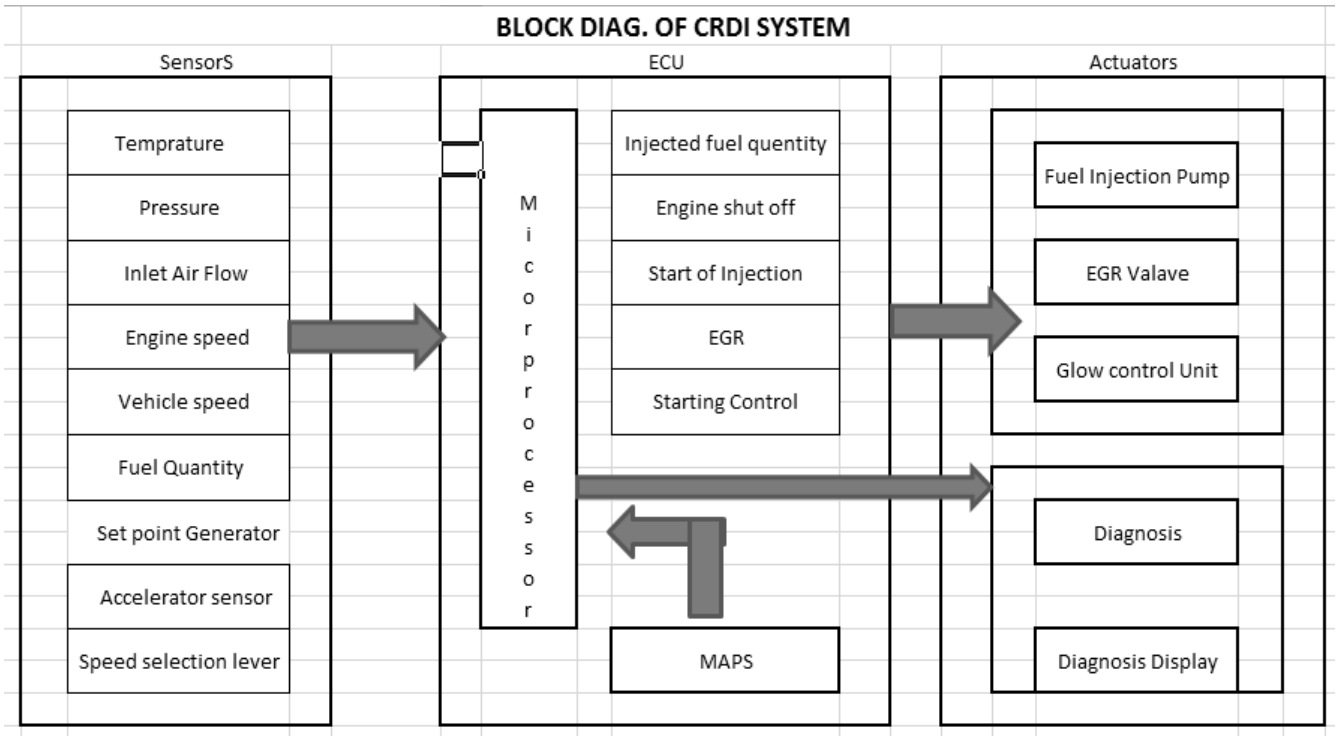
2

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

| b) Draw the block diagram of CRDI system and describe its working. State its two advantages. | 6 |
|---|---|

**Answer: Working of CRDI System:**

i. In the common rail direct injection system different sensors are used for operation. These sensors collect information about engine operating condition and send signal to the CRDI System.
ii. Microprocessor receives the sensor signals, converts the signal in required format and then processes the signals. e.g. Analog signals are converted into digital signals. Digital signals are amplified. Then the data is compared with the look- up tables. In the Logic and power modules, the actuators are controlled for desired control of the system. The actuators include Fuel injectors, EGR valve, Glow control unit etc. 2
ii. The signal to the actuators is given in the required form like analog signals.
v. Information is also available in form of Diagnostic trouble codes at the dashboard. It can also be availed from the EDC using a scan tool.




2

2

**Advantages:** *(Any 2 advantages)*

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

| | |
|---|---|
| 2. Attempt **any four** : | 16 |
| a) Draw a neat labeled P-$\theta$ diagram showing the stages of combustion in SI engine. | 4 |

**Answer:- Pressure – Crank Angle Diagram showing stages of combustion in spark ignition engine**
***(Note: Correct diagram – 3 marks, Labels -01mark)***

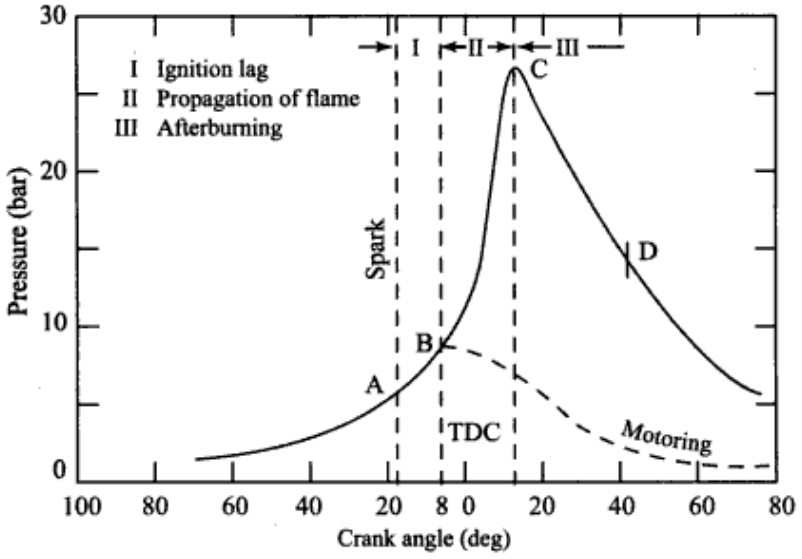



*Fig. Stages of Combustion in an SI Engine*

4

| | |
|---|---|
| b) Compare knocking in SI and CI engine | 4 |

**Answer: Comparison:** *(4 points- 1 mark each); 2 Marks should be given to diagram, if only diagram is drawn.*

| Sr. No | **Detonation in SI Engine** | **Knocking in CI Engine** |
|---|---|---|
| 1 | It occurs by the end of combustion. | It occurs by the start of combustion. |
| 2 | Homogenous charge causes strong pressure waves and more damage to the engine. | Heterogeneous charge causes pressure waves to set up and to cause discomfort to the occupants. |
| 3 | Highest useful compression ratio is limited by detonation. | Higher compression ratio tends to reduce the Engine knocking. |
| 4 | Detonation is easily detected. | Knocking is difficult to detect. |

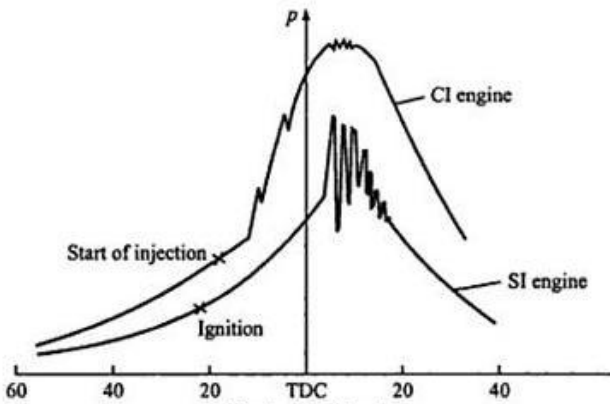
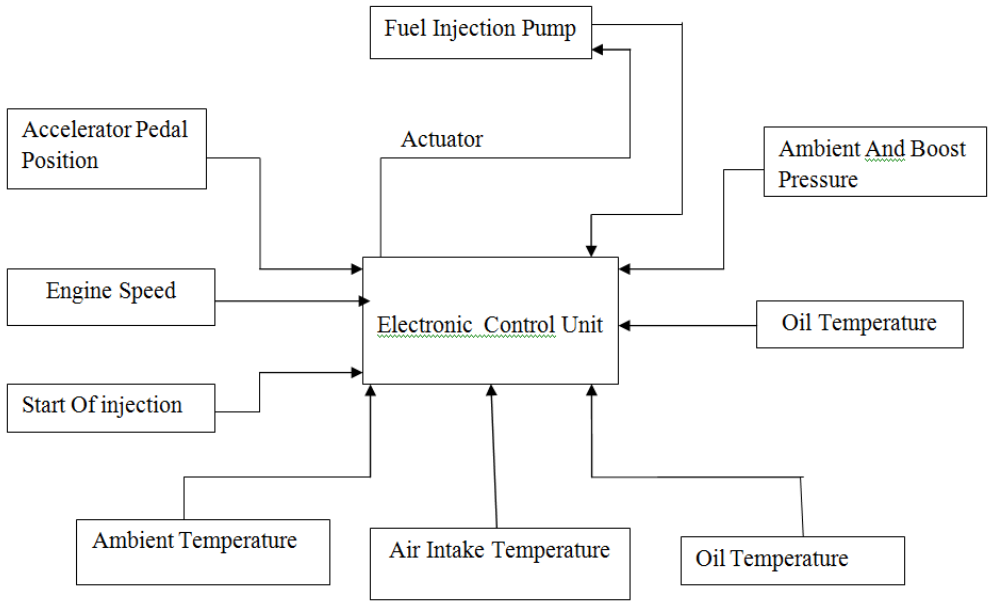



Figure Comparison of knock in SI and CI engines.

4

| | |
|---|---|
| c) List four sensors used in MPFI engine and state their functions. | 4 |
| Answer: **Sensors and their function:** *(Any 4, 1 mark each)*<br>**1) Oxygen sensor:** It is used to monitor the amount of oxygen in the exhaust gas .<br>**2) Mass air flow (MAF) sensor:** It is used to tell the ECU the mass of air entering the engine<br>**3) Coolant temperature sensor:-**Measures the temperature of the coolant in the system and sends signal to ECU.<br>**4) Throttle position sensor**. It supplies information to the ECU about the position the throttle is in.<br>**5) Crank position sensor:-**It supplies information to the ECU about the position and rotation of the Crank shaft.<br>**6) Manifold absolute pressure sensor:-** Senses pressure in the intake manifold and same information is given to ECU.<br>**7) Vehicle speed sensor**:-Sends electrical pulses to the ECU about the speed of vehicle.<br>**8) Cam Sensor**:-It senses cam position and corresponding signal is sent to the ECU.<br>**9) Knock Sensor**:-It detects the vibrations generated during the combustion process and supplies signal to the ECU. | 4 |
| d) Describe the working of electronically controlled diesel injection pump. | 4 |
| **Answer: Electronically controlled diesel injection pump:**<br>This is similar to conventional pumps, but its injection is controlled by Electronic Control Unit (ECU) which control solenoid valve in the injection pump**.**<br>The pump speed and timing sensor is mounted on the end of the pump camshaft. The ECU receives signals like accelerator pedal position, engine and road speeds, gear selected, start of injection, control rod position, induction manifold, and fuel temperatures etc. Generally ECU output is the current to the solenoid valve for actuating the pump control rod, and to the injection advance and retard mechanism. Based on these data, the ECU accordingly modifies the current to the solenoid valve, to supply fuel as per requirement. | 3 |
|  | 1 |

| | |
|---|---|
| e) State two advantage and two disadvantage of electric cars. | 4 |
| Answer: **Answer:**<br>**Advantages of Electric Car:**<br>1. Rapid acceleration<br>2. Noise free operation<br>3. No exhaust fumes<br>4. High reliability<br>5. Easy maintenance<br>6. Regenerating braking<br>7. No loss power in idling.<br>8. Easy to drive<br><br>**Disadvantages Of Electric Car:**<br>1. Need to charge the batteries.<br>2. The top speed is quite low.<br>3. Life of batteries quite short<br>4. More expensive to replace the batteries.<br>5. Not suitable for heavy vehicles<br>6. Limited power. | 2<br><br>2 |
| f) What is diesel smoke? State two methods to control diesel smoke. | 2 |
| Answer:<br><br>**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.<br><br>**Methods of controlling diesel smoke : (Any 2 methods)**<br>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.<br>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.<br>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.<br>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<br><br>2 |

| | |
|---|---|
| 3. Attempt **any four** : | 16 |
| a)What are the effects of detonation ? Explain in brief. | 4 |
| **Answer: (Any 4- 1 mark each)**<br><br>**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.<br><br>**2. Mechanical damage:** Due to rapid pressure waves, rate of wear is increased and piston head, cylinder head and valves may be pitted.<br><br>**3. Carbon deposits:** Detonation results in increased carbon deposits.<br><br>**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.<br><br>**5. Decrease in power output and efficiency:** Due to increase in the rate of heat transfer the power output is decreased.<br><br>**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. | 4 |
| b) State the effect of following factor on ignition lag and flame propagation of SI engine.<br>i) Compression ratio<br>ii) Turbulence. | 4 |
| **Answer:-**<br>**Factors effect on Ignition lag and flame propagation:-**<br>**1) Compression ratio**: A higher compression ratio increases the pressure and temperature of the working mixture and decreases the concentration of the residual gases. These favorable conditions reduce the ignition lag of combustion.<br>High pressure and temperature of the compressed mixture speeds up the flame propagation. 2<br><br>**2) Turbulence:** Ignition lag is not much affected by turbulence intensity. 2<br>The flame speed is very low in non turbulent mixture. A turbulent motion of the mixture intensifies the processes of heat transfer and mixing of the burned / unburned portions in the flame front. | |
| c) Compare Throttle body injection (TBI) with port fuel injection (PFI) systems. | 4 |
| **Answer:** (Any 4 points of difference, 1 mark each) | |

| Sr. No. | TBI system | PFI System |
|---|---|---|
| 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 |

| Sr. No. | TBI system | PFI System |
|---|---|---|
| 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. | Hither power output due to low resistance at intake manifold and higher volumetric efficiency. |

4

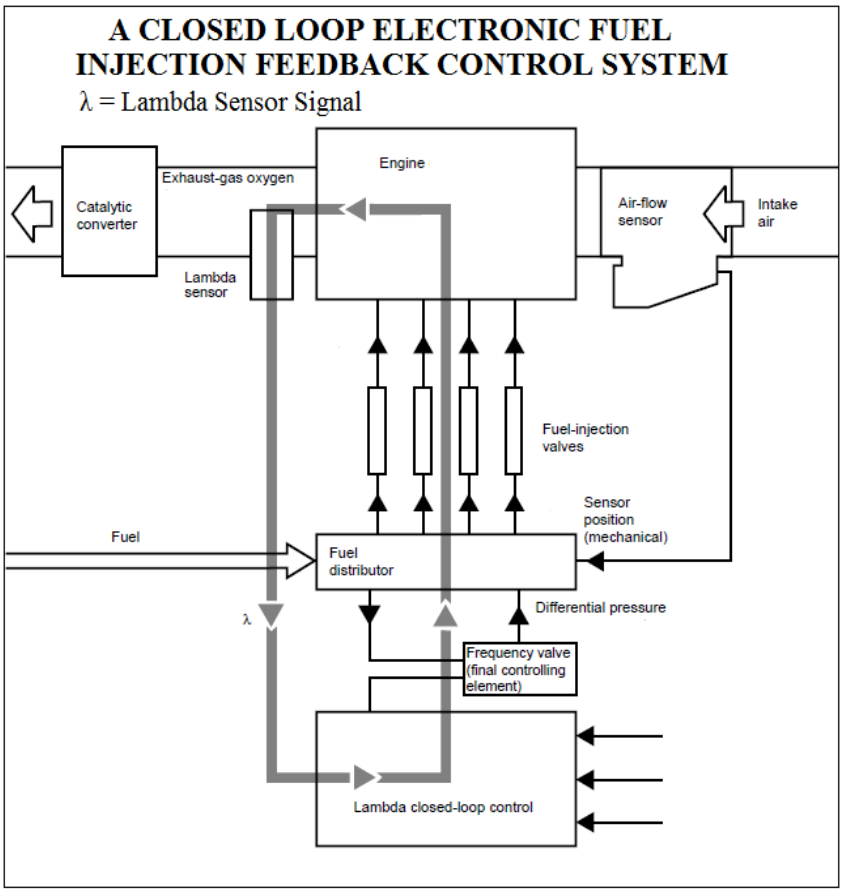
c) Draw a schematic diagram of a closed loop EFI feedback control system. What is its purpose? 4

**Answer: Schematic diagram of a closed loop EFI feedback control system:**

**Purpose:-**

More fuel is deliver when O2 contain is detected and less fuel when it is not. in this way a accurate air fuel mixture close to the chemically correct ratio is maintained ( lambda=0.99 to 1) .This produces the correct exhaust gas constituents for chemical reaction in the catalytic convertor and catalytic convertor works with its best efficiency of about 90%.

1




3

e) State four environmental benefits of biodiesel in comparison to petroleum based fuels. 4

Answer: Environmental **benefits of biodiesel** in comparison to petroleum based fuels *(Any 4- 1 mark each)* 4

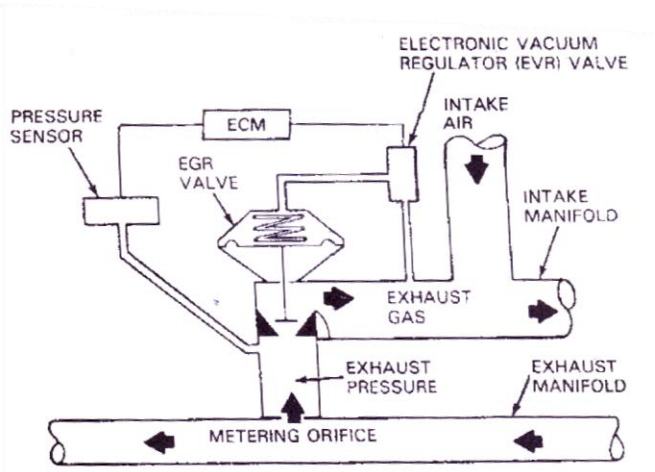
i) It is a renewable substitute fuel for petroleum diesel.
ii) It has lower exhaust emissions
iii) It is biodegradable fuel
iv) It is non-toxic.
v) It is free of sulphur and aromatics.
vi) It is an environmentally friendly fuel that can be used in any diesel engine without modification.

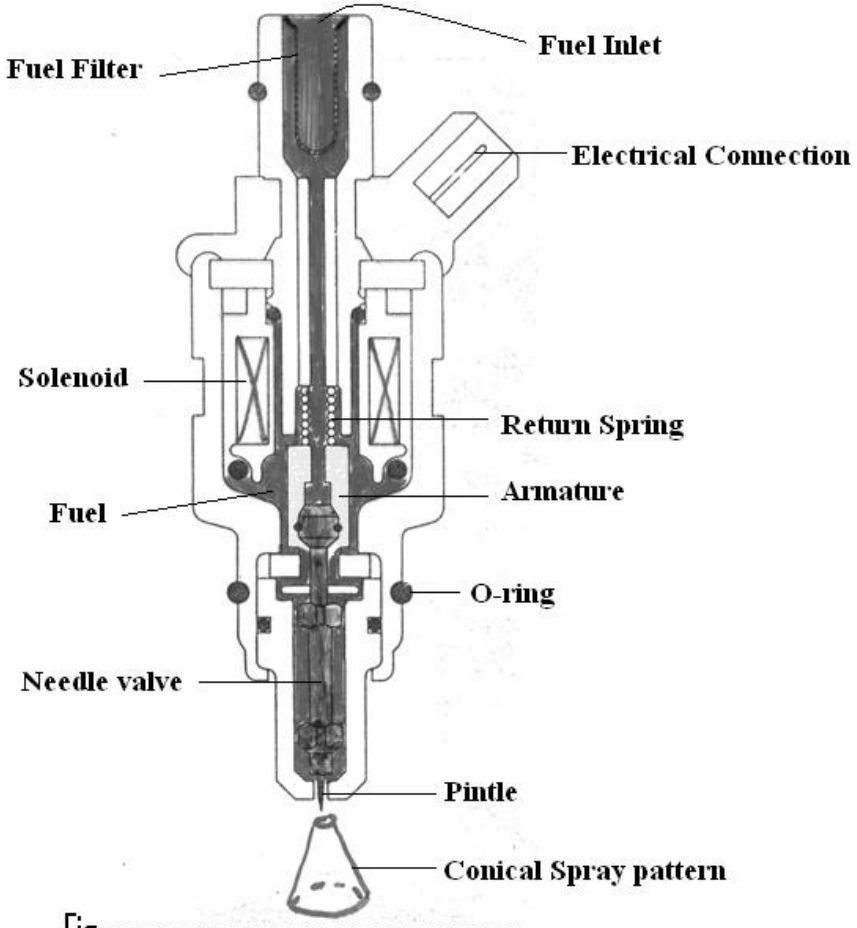
f) Describe the concepts of Gasoline Direct Injection (GDI). 4

**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. **4**

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. A) Attempt **any Three:** | 12 |
| a) What are the advantages and disadvantages of the IDI swirl chamber over the open chamber design of combustion chamber? | 4 |
| **Answer: Advantages:** *(Any2 – 2 marks)*<br>1) Due to strong swirl a single orifice injector with low injection pressure is required.<br>2) Due to strong swirl there is a greater utilization of air.<br>3) In the swirl chamber design the injector is located towards the one side of cylinder; hence there is freedom to use larger valves.<br>4) In this chamber swirl is proportional to speed. Thus they are suitable for variable speed operation.<br>5) It reduces delay period and hence low ignition quality fuel can be used.<br>6) It produces smoother engine operation.<br>7) Due to use of single Pintle type injector, maintenance is less.<br>8) In this, large valves are used so it gives higher volumetric efficiency.<br>**Disadvantages:** *(Any2 – 2 marks)*<br>1) Cold starting trouble due to high heat loss because of strong swirl & greater surface volume ratio.<br>2) Work absorb in producing swirl, hence mechanical efficiency is lower.<br>3) Cylinder more expensive in construction.<br>4) This chamber utilizes less excess air.<br>5) It gives lower indicated efficiency 5 to 8% more fuel consumption.<br>6) More energy is wasted in the exhaust gases, thus it reduces the exhaust valve life. | 2<br>2 |
| b) What does VTEC stands for? State its two advantages. | 4 |
| **Answer:**<br>VTEC stands for **Variable valve timing and electronic lift control**.<br>**In VTEC, the valve timing and the valve lift is controlled using ECU to provide efficient breathing of engine and efficient performance of engine.**<br>**Advantages:** *( Any Two- 2 marks)*<br>1) Increased fuel efficiency and<br>2) High power output.<br>3) Emissions levels can also be more accurately controlled with the GDI system.<br>4) Improved Volumetric Efficiency<br>5) GDI allows a high compression ratio of 12, and thus improved combustion efficiency<br>6) GDI uses leaner mixture i.e 65:1<br>7) Improve drivability. | 2<br>2 |
| c) State the Methods of controlling Gasoline engine emissions. Describe one Method. | 04 |
| **Answer: Methods of controlling Gasoline engine emissions:**<br>*(Methods -2 marks, Description any one method – 2 marks*)<br>1) Modifications in the Engine Design.<br>2) Exhaust Gas Treatment.<br>3) Fuel modification:<br>**1. Modifications in the Engine Design :-**<br>i) Reduced surface: volume ratio, lower compression ratio and quenching zone reduce HC emission.<br>ii) Induction system may be modified to provide relatively lean and stable air-fuel mixtures. | 2 |

| | |
|---|---|
| iii) Optimum ignition advance reduces NOx emission while reduce valve overlap controls engine emission.<br><br>**2. Exhaust Gas Treatment:** The exhaust gases coming out of exhaust manifold are treated to reduce HC, CO and Nox emission. Devices like catalytic convertor, after burner, exhaust gas Reactor effectively reduce these pollutants.<br><br>**3. Fuel modification:-**<br>1. Lead free fuel: Fuel must be such that it should not have any sulphur, otherwise it leads to many operating difficulties and produce undesirable pollutants.<br>2. Fuel Volatility: Fuel volatility is compromise of high volatility and low volatility to control the pollution. | 2 |
| d) Draw a labeled sketch of EGR valve and describe its working. | 4 |
| **Answer: Exhaust Gas recirculation:**<br>EGR System control by the ECM. A pressure sensor monitors the exhaust system pressure. The sensor signals this information to the ECM. The ECM sends the signal to electronic vacuum regulator valve (EVR) to open and close the EGR valve. Thus it controls the amount of exhaust gas recalculated.<br><br>  <br><br>**EGR valve controlled by the ECM through the electronic vacuum regulator (EVR) valve.** | 2<br><br>2 |
| B) Attempt **any one :** | 6 |
| a) Draw a labeled sketch of TOP feed electric fuel injector and describe its working. | 6 |
| **Answer: Working of TOP feed electric fuel injector:**<br><br>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.<br><br>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). | 3 |

| | |
|---|---|
| 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.<br>  <br><br>Fig. TOP FEED FUEL INJECTOR | 3 |
| b) Draw a neat labeled block diagram of CNG conversion kit. Describe its working. | 6 |
| **Answer: Working of CNG Kit:**<br><br>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. | 3 |

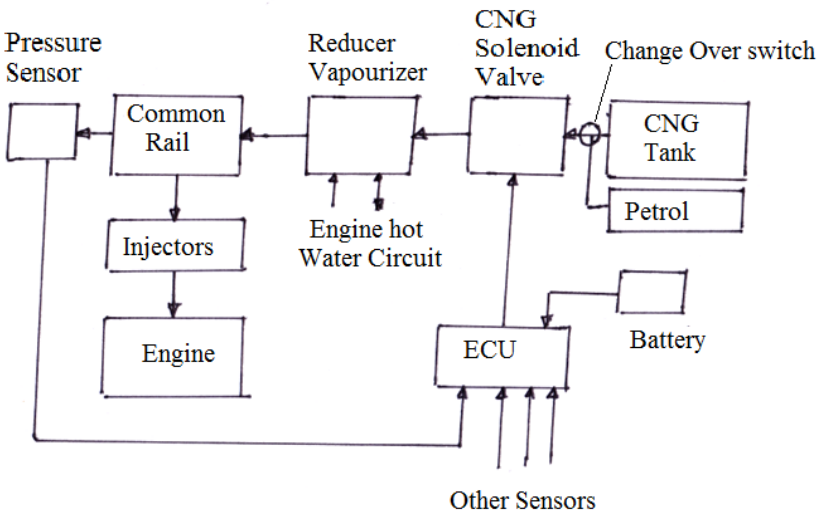



Figure: CNG Kit

3

5. Attempt **any two** : 16

a) How the following factors will affect the delay period in CI engine?
i) Ignition quality of fuel
ii) Injection timing
iii) Compression ratio
iv) Engine speed
v) Air fuel ratio
vi) Load
vii) Engine size
viii) Type of combustion chamber

8

**Answer**:

| Sr. No | Parameter | Effect on the Delay Period in C.I. Engine |
|---|---|---|
| i | Ignition quality of fuel | A lower self ignition temperature means a lower delay period. |
| ii | Injection timing | Delay period increases with increase in injection advance angle. |
| iii | Compression ratio | Increased Compression Ratio reduces delay period and vice versa. |
| iv | Engine speed | As engine speed increases, delay period decreases. |
| v | Air fuel ratio | As air: fuel ratio decreases, delay period decreases. |
| vi | Load | Delay period increases with load. |
| vii | Engine size | Large engines operate at low speed thus increasing delay period in terms of crank angle |
| viii | Type of combustion chamber | A pre-combustion chamber gives a shorter delay period as compared to an open type of combustion chamber. |

8

b) Describe the idle speed control as output control function of an electronic control module with neat sketch. 8

**Answer: Idle Speed Control as Output function of a ECM:**

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. 5
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.

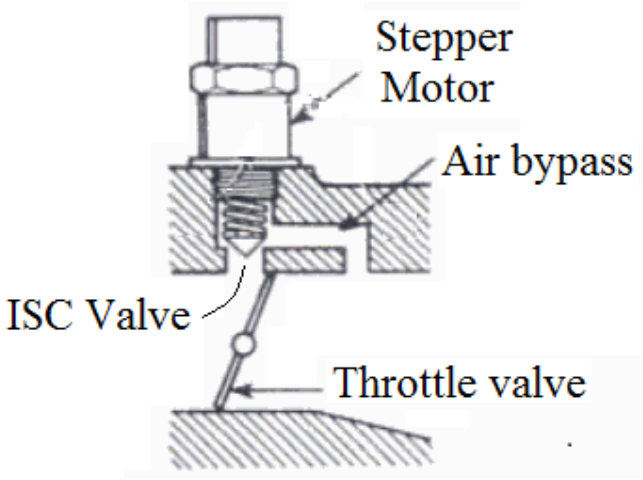



Figure: Idle Speed Control 3

c) i) What is glow plug? Why and where it is used? 8
ii) Draw a labelled circuit diagram of glow plug and describe its operation.

**Answer:**

i) **Glow Plug**: Glow plug is an aid for cold starting of a C.I. engine.

**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 Compression Ignition Engines. The glow plug heats to starting temperature (approx. 850°C) as rapidly as possible.

**Location of Glow Plug**: Plug location within the combustion chamber is selected to ensure access to an ignitable mixture. Modern glow plugs heat to required temp in roughly 4 seconds. 2

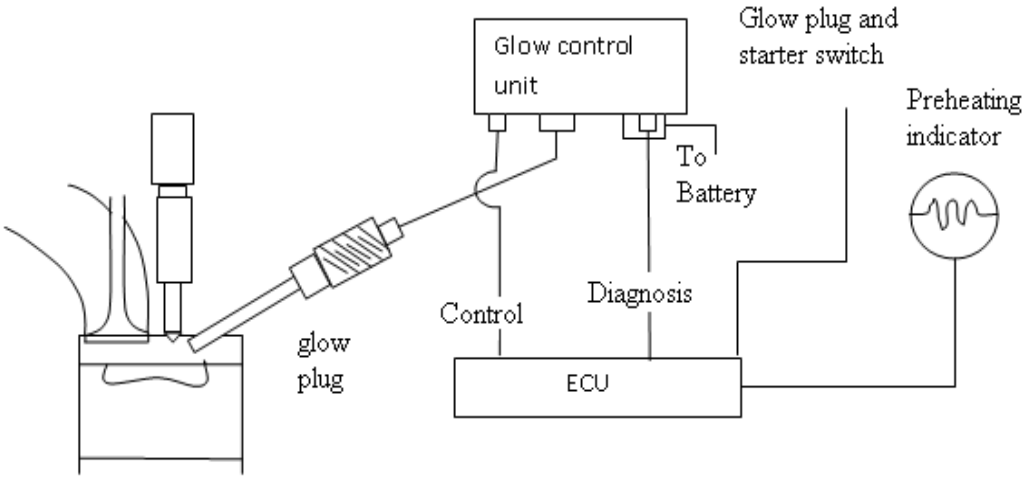
In Pre-chamber engine (two section – Indirect injection engine combustion chamber), glow plugs are installed which extend into the secondary chamber. On D.I engines, the glow element extends into the main combustion chamber.

ii) **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 3

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.




ECU Controlled Glow Plug System on D.I. Engine — 3

| | |
|---|---|
| 6 Attempt **any four:** | 16 |
| a) i) identify the diagram given in figure 1.<br>ii) Label it and state its two advantages. | 4 |
| **Answer:** This is combustion chamber of a Four stroke engine with Overhead Valve layout. | 1 |
| **Advantages:** 1. It has higher volumetric efficiency as larger valves are accommodated.<br>2. It has better scavenging and cleaner combustion. | 1 |

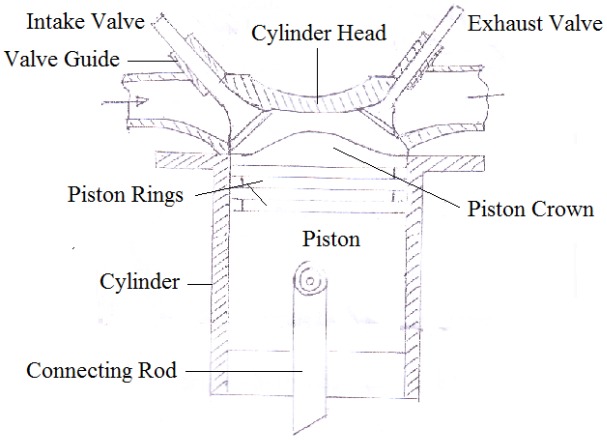



Fig: Four Stroke Engine Combustion Chamber. — 2
Overhead Valve Engine

b) Compare variable geometric turbocharger with conventional turbocharger. 4

Answer: Comparison: variable geometric turbocharger with conventional turbocharger
*(Any 4 points-1Mark each)*

| Sr. No. | Parameter | Variable Geometry Turbocharger | Conventional Turbocharger |
|---|---|---|---|
| 1 | Fuel efficiency | Improved fuel efficiency by 20 % | Lower fuel efficiency as compared with VGT. |
| 2 | Turbo- lag | Reduced Turbo-lag | More turbo-lag. |
| 3 | Power output | Higher power output even at lower speed | Lower power output at lower speeds |
| 4 | Boost pressure at low speeds | Adequate | Low |
| 5 | Boost pressure at high speeds | It is not excessive. So, Waste gate boost control is not needed. | Increased boost pressure requires Waste gate boost control. |
| 6 | Engine response | Quick responsive engine | Sluggish response at low engine speeds. |

4

c) What are the major pollutants from the exhaust of gasoline engines? What are the environmental effects of these pollutants? 4

**Answer: Major Pollutants from Gasoline engine exhaust.**

| Pollutant | Environmental Effect of Pollutants |
|---|---|
| 1. Hydrocarbons | They play an important role in forming NO2 and O3 which are health and environmental hazards. |
| 2. Carbon Monoxide | CO is a highly poisonous gas that can cause dizziness, headaches, impaired thinking, and death by O2 starvation. It can affect the central nervous system, impairing physical coordination, vision and judgment, creating nausea and headaches, reducing worker productivity and increasing personal discomfort. |
| 3. Carbon dioxide | CO2 is a greenhouse gas and may be the major cause of global warming. |
| 4. Oxides of Nitrogen | NO is unhealthy and contributes to the greenhouse effect. NO2 is a very toxic gas and contributes to the formation of smog, ozone, and acid rain. |

4

d) State the Euro norms and Bharat stage norms for diesel cars. 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 and Euro emission norms containing permissible levels of pollutants.*

**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.

**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

| | |
|---|---|
| e) How is the $NO_x$ formed in the exhaust of I.C. engines? What are the important engine variables that effect $NO_x$ emission? | 4 |
| **Answer:**<br>NOx is formed in the combustion chamber of an I.C. engine. The formation of NOx is the result of high combustion temperatures and pressures. When combustion temperatures reach more than 1,261°C, the N and the O2 in the air begin to combine and form NOx. Its production increases as the temperature inside the combustion chamber rises due to acceleration or heavy engine loads.<br><br>**Engine variables affecting NOx emission are as follows:**<br>1. Combustion chamber temperature<br>2. Cylinder pressure<br>3. Engine load<br>4. Air: fuel ratio<br>5. Engine speed<br>Therefore, the best way to decrease the production of NOx is to hold down the temperature in the combustion chamber. The EGR system is used to reduce the amount of NOx in the exhaust. | 2<br><br>2 |