basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

# NATIONAL SENIOR CERTIFICATE

## GRADE 12

## MECHANICAL TECHNOLOGY: AUTOMOTIVE

## NOVEMBER 2019

## MARKING GUIDELINES

**MARKS: 200**

**These marking guidelines consist of 20 pages.**

## QUESTION 1: MULTIPLE-CHOICE (Generic)

1.1 B ✓ (1)

1.2 C ✓ (1)

1.3 A ✓ (1)

1.4 C ✓ (1)

1.5 A ✓ (1)

1.6 C ✓ (1)
**[6]**

## QUESTION 2: SAFETY (Generic)

2.1 **Machine safety rule:**

- Know how to switch the machine off / emergency stop. ✓
- Wear personal protective equipment (PPE). ✓
- Know how to use the machine. ✓
- Ensure that all guards are in place. ✓
- No tools lying on the machine. ✓
- Work piece is properly secured. ✓
- Check the condition of the machine. ✓
- Follow manufacture's specifications before operating a machine. ✓
- Operator must have authorization to working on a machine. ✓
- Make sure the machine is not locked out. ✓
- Ensure that the machine setup is correct and safe. ✓
- Ensure that the machine area is clean and safe. ✓

(**Any 1 x 1)** (1)

2.2 **Drill press safety precautions:**

- To prevent injuries. ✓
- To improve accuracy. ✓
- To prevent work piece rotating / moving. ✓
- To prevent the drill bit from breaking. ✓

(**Any 1 x 1)** (1)

2.3 **Hydraulic press safety rules:**

- Make sure the press is in a good working condition. ✓
- Take notice of the pre-determined maximum pressure of the hydraulic press. ✓
- Make sure the area around the press is clean and free of oil, grease and water. ✓
- Ensure that the platform is rigid and square to the cylinder. ✓
- Ensure that suitable jigs and prescribed equipment is available. ✓
- Check hydraulic pipes for leaks or cracks. ✓
- Check supporting pins are not worn out and fitted properly. ✓
- Check fluid levels. ✓
- Compressive force must be applied at 90° to the object. ✓
- Check cable and pulleys on the platform if equipped. ✓
- Correct PPE. ✓
- Pressure gauge must be checked and calibrated. ✓
- Ensure that all guards are in place. ✓

**(Any 2 x 1)** (2)

2.4 **Reasons for wearing surgical gloves:**

- To prevent HIV/AIDS or any blood related infections being transmitted. ✓
- To prevent contamination of the open wounds. ✓ (2)

2.5 **Safe handling of portable electrical equipment:**

- Ensure the electrical cord and plug, are in a good condition. ✓
- Ensure all safety guards are in place. ✓
- Ensure that the correct attachments (drill bits, blades etc.) are fixed in the correct way. ✓
- Do not force the machine / equipment. ✓
- Operate according to manufacturer instructions. ✓
- Avoid contact with water. ✓
- Keep the cable away from heat, oil, sharp edges and moving parts. ✓
- Make sure that the wires don't wrap around each other. ✓
- Avoid dropping the machine. ✓
- Check the condition of the equipment. ✓

**(Any 2 x 1)** (2)

2.6 **Responsibility of employer:**

- Provide and maintain working systems, work area, equipment and tools in a safe condition. ✓
- Eliminate or reduce any potential hazard. ✓
- Produce, handle, store and transport goods safely. ✓
- Ensure that every person employed complies with the requirements of this OHS Act. ✓
- Enforce measures if necessary in the interest of health and safety. ✓
- Appoint a person who is trained and who have the authority to ensure that the employee takes precautionary measures. ✓
- Inform employees of the hazards to his health and safety attached to any duty or work situation. ✓
- Provide first aid equipment. ✓

**(Any 1 x 1)** (1)

2.7 **Responsibility of employee:**

- Pay attention to their own and other people's health and safety. ✓
- Co-operate with the employer regarding the OHS Act. ✓
- Carry out a lawful order given to them. ✓
- Report any situation that is unsafe or unhealthy. ✓
- Report all incidents and accidents. ✓
- Not to interfere with any safety equipment or misuse such equipment. ✓
- Obey all safety rules. ✓

**(Any 1 x 1)** (1)
**[10]**

## QUESTION 3: MATERIAL (Generic)

3.1 **Filing test:**

- Use the right ✓ filing skills. ✓
- File on the tip or edge ✓✓ of the metal.
- By applying chalk ✓ to the file surface. ✓

**(Any 1 x 2)** (2)

3.2 **Purpose of heat treatment of steel:**

Heat treatment of steel is done to change ✓ the properties / grain structure ✓ of steel. (2)

3.3 **Reasons for tempering hardened steel:**

- To reduce ✓ the brittleness ✓ caused by the hardening process.
- To relieve ✓ strain ✓ caused during hardening process.
- To increase ✓ the toughness ✓ of the steel.
- To give hardened work piece a more ✓ fine-grained structure. ✓

**(Any 2 x 2)** (4)

3.4 **Heat treatment processes on steel:**

3.4.1 **Annealing:**

- The steel is heated to the prescribed temperature. ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then cooled very slowly to produce maximum softness. ✓ (3)

3.4.2 **Hardening:**

- The steel is heated slightly higher than the upper critical temperature. ($AC_3$) ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then rapidly cooled by quenching in rapid cooling medium. ✓ (3)

**[14]**

## QUESTION 4: MULTIPLE-CHOICE QUESTIONS (Specific)

| | | |
|---|---|---|
| 4.1 | A ✓ | (1) |
| 4.2 | C ✓ | (1) |
| 4.3 | D ✓ | (1) |
| 4.4 | B ✓ | (1) |
| 4.5 | C ✓ | (1) |
| 4.6 | D ✓ | (1) |
| 4.7 | A ✓ | (1) |
| 4.8 | B ✓ | (1) |
| 4.9 | C ✓ | (1) |
| 4.10 | B ✓ | (1) |
| 4.11 | C ✓ | (1) |
| 4.12 | D & B ✓ | (1) |
| 4.13 | B ✓ | (1) |
| 4.14 | B ✓ | (1) |
| | | **[14]** |

## QUESTION 5: TOOLS AND EQUIPMENT (Specific)

5.1 **Cylinder leakage tester:**

5.1.1 **Labels:**
A – Pressure control valve / Knob / Regulator ✓
B – Gauge / Meter ✓
C – Compressor hose / Air hose / Pipe ✓
D – Spark plug connector / adapter / Hose / Pipe ✓ (4)

5.1.2 **Purpose of cylinder leakage tester:**
- To determine the percentage ✓ of gas leakage from a cylinder. ✓
- To determine the location ✓ of gas leaks from a cylinder. ✓

**(Any 1 x 2)** (2)

5.1.3 **Procedure for cylinder leakage test:**
- Turn the crank shaft until both valves on cylinder no. 1 are closed (piston no.1 is on power stroke). ✓
- Remove the spark plug and connect the spark plug adaptor (tester) to the spark plug hole. ✓
- Use a spanner to lock the crankshaft pulley so that it cannot turn. ✓
- Release air into the cylinder according to the prescribed pressure. ✓
- The reading will indicate the percentage gas leakage. ✓
- A hissing sound at various points indicates the location of the leak. ✓ (6)

5.2 **Compression tester:**

5.2.1 **Purpose of compression test:**
- To determine the amount of compression pressure ✓ from a specific cylinder during compression stroke (BDC – TDC). ✓
- To determine the condition ✓ of the engine's valves, valve seats and piston rings. ✓

**(Any 1 x 2)** (2)

5.2.2 **Compression tester release valve:**
- Remove the pressure from the gauge ✓ to ensure an accurate reading. ✓
- Remove the pressure from the gauge ✓ to prevent damage to the gauge. ✓

**(Any 1 x 2)** (2)

5.3 **Gases analysed:**

- Carbon monoxide (CO) ✓
- Hydrocarbon (HC) ✓
- Carbon dioxide ($CO_2$) ✓
- Nitrogen oxide (NOx) ✓
- Sulphur dioxide($SO_2$) ✓
- Oxygen ($O_2$) ✓

**(Any 2 x 1)** (2)

5.4 **Purpose of turn tables:**

Turn table makes it possible to turn ✓ the front wheels when conducting wheel alignment settings. ✓ (2)

5.5 **Outcomes of dynamic wheel balancing is to check:**

- The plane of imbalance. ✓
- The extent of unbalancing forces. ✓
- The direction of these forces. (clockwise or counter-clockwise) ✓
- Wheels balanced on all planes. ✓
- Less vibration on the steering. ✓
- Even tyre wear. ✓

**(Any 3 x 1)** (3)

**[23]**

## QUESTION 6: ENGINES (Specific)

6.1 **Crankshaft vibration:**

- The action upon the shaft of unbalanced forces. ✓
- The torsional or twisting effect of the power strokes upon the shaft. ✓
- Worn vibration damper. ✓
- Uneven flywheel wear. ✓
- Unbalanced crankshaft. ✓

**(Any 2 x 1)** (2)

6.2 **Vibration Damper:**

6.2.1 Vibration damper ✓ (1)

6.2.2 **Labels:**
A – Crankshaft ✓
B – Crankshaft flange / pulley ✓
C – Secondary flywheel ✓
D – Friction disc / Rubber ✓
E – Friction spring ✓
F – Spring plate / Disc ✓ (6)

6.2.3 The vibration damper adds mass to the crankshaft on the opposite side ✓ of the normal flywheel in order to counteract the torsion of the crankshaft. ✓ (2)

6.3 **Firing order of an engine:**

- The position of the cranks on the crankshaft. ✓
- The arrangement of the cams on the camshaft. ✓ (2)

6.4 **'V8' angle:**
90° ✓ (1)

6.5 **Intercooler:**
To cool the air that has been compressed by the turbo-charger. ✓ (1)

6.6 **Purpose of a supercharger:**

- To fill the cylinder with an increased air pressure ✓ that is higher than atmospheric pressure. ✓
- To increase ✓ the compression pressure ✓ in the cylinder.
- To increase ✓ the volumetric efficiency ✓ of the engine.
- To improve ✓ the performance. ✓

**(Any 1 x 2)** (2)

6.7 **Centrifugal supercharger:**

6.7.1 Centrifugal supercharger / blower ✓ (1)

6.7.2 **Labels:**
A – Air inlet ✓
B – Air outlet / Exhaust ✓
C – Casing / Housing / Cover / Body ✓
D – Impeller / Turbine ✓
E – Fins / Vanes / Blades ✓ (5)

6.7.3 **Operation:**

- This blower can be driven mechanically by means of a belt drive from the crankshaft. ✓
- The shaped fins on the impeller move the air around to the outer edge of the impeller into the housing. ✓
- The rotating fins leave a low pressure behind it. ✓
- Due to atmospheric pressure, air rushes in to fill the low pressure at the centre of the impeller. ✓
- The impeller rotates so fast that a continuous movement of air is present, which now builds up a pressure as it is thrown at the rim or the edge. ✓ (5)

**[28]**

## QUESTION 7: FORCES (Specific)

7.1 **Swept volume:**

Volume when the piston moves ✓ from bottom dead centre to top dead centre. ✓ (2)

7.2 **Method to increase compression ratio:**

- Remove shims between the cylinder block and cylinder head. ✓
- Fit thinner cylinder head gasket. ✓
- Machine metal from cylinder head. ✓
- Fit a piston with a higher crown. ✓
- Fit a crankshaft with a longer stroke / through. ✓
- Increase the bore of the cylinders / bigger pistons. ✓

**(Any 3 x 1)** (3)

7.3 **Compression ratio:**

7.3.1 **Swept volume:**

$$\text{Swept Volume} = \frac{\pi D^2}{4} \times L \quad ✓$$

$$= \frac{\pi (9{,}0)^2}{4} 10{,}0 \quad ✓$$

$$= 636{,}17 \text{ cm}^3 \quad ✓$$

(3)

7.3.2 **Original clearance volume:**

$$\text{Compression Ratio} = \frac{SV + CV}{CV}$$

$$CV = \frac{SV}{CR - 1} \quad ✓$$

$$= \frac{636{,}17}{10{,}5 - 1} \quad ✓$$

$$= \frac{636{,}17}{9{,}5}$$

$$= 66{,}97 \text{ cm}^3 \quad ✓$$

(3)

7.3.3 **New bore diameter:**

$$\text{New compression ratio} = \frac{SV}{CV} + 1 \quad \checkmark$$

$$11:1 = \frac{SV}{66,97} + 1 \quad \checkmark$$

$$SV = 66,97 \times 10$$

$$\frac{\pi D^2}{4} \times L = 669,7 \quad \checkmark$$

$$D^2 = \frac{669,7 \times 4}{\pi \times 10}$$

$$D = \sqrt{85,27} \quad \checkmark$$

$$= 9,23\,cm \quad \checkmark$$

$$= 92,34\ mm \quad \checkmark$$

(6)

7.4 **Power:**

7.4.1 **Indicated Power:**

$$IP = P \times L \times A \times N \times n$$

$$P = 1300\ kPa$$

$$L = \frac{160}{1000}$$

$$= 0,16\,m \quad \checkmark$$

$$A = \frac{\pi D^2}{4}$$

$$= \frac{\pi\, 0,12^2}{4}$$

$$= 1,13 \times 10^{-2}\ m^2 \quad \checkmark$$

$$N = \frac{4500}{60 \times 2}$$

$$= 37,5\ ps/s \quad \checkmark$$

$$n = 4\ cylinders$$

$$IP = P \times L \times A \times N \times n$$

$$= \left(1300 \times 10^3\right) \times 0,16 \times \left(1,13 \times 10^{-2}\right) \times 37,5 \times 4 \checkmark$$

$$= 352560$$

$$= 352,56\ kW \quad \checkmark$$

(5)

7.4.2 **Brake Power:**

$$BP = 2\pi \times N \times T$$

$$= 2\pi \times 610 \times \frac{4500}{60} \quad \checkmark\checkmark$$

$$= 2\pi \times 610 \times 75$$

$$= 287455{,}73 \text{ W} \quad \checkmark$$

$$= 287{,}46 \text{ kW} \quad \checkmark \qquad (4)$$

7.4.3 **Mechanical efficiency:**

$$\text{Mechanical efficiency} = \frac{BP}{IP} 100\%$$

$$= \frac{287{,}46}{352{,}56} \times 100\% \quad \checkmark$$

$$= 81{,}54\% \quad \checkmark \qquad (2)$$

7.5 **Mechanically efficiency** is based on the relationship of the power developed within the engine ✓ and the actual brake power delivered at the fly wheel. ✓ (2)

7.6 **Brake Power** is the useable power ✓ developed at the flywheel. ✓ (2)

**[32]**

## QUESTION 8: MAINTENANCE (Specific)

8.1 **Radiator cap pressure test:**

- Install the cap on the cooling system pressure tester. ✓
- Pump up the tester while watching the pressure gauge. ✓
- The pressure cap should release air at the rated pressure stamped on the cap. ✓
- The cap should hold the pressure for at least one minute. ✓
- If not install new cap. ✓ (5)

8.2 **Causes and correction for pressure drop:**

**Causes:**

- Leaks between components of the cooling system. ✓
- Leaks at water hose. ✓
- Blown cylinder head gasket. ✓
- Leaks at water pump. ✓
- Leaks at radiator. ✓
- Leaks at corroded welsh or core plug. ✓
- Leaks at interior heater radiator. ✓
- Leaks at heater tap. ✓

**(Any 2 x 1)**

**Corrections:**

- Renew the gaskets and seals. ✓
- Renew faulty hoses and secure clamps. ✓
- Skim the cylinder head and replace cylinder head gasket. ✓
- Renew water pump. ✓
- Renew the radiator. ✓
- Renew welsh or core plugs. ✓
- Renew interior radiator. ✓
- Renew radiator tap. ✓

**(Any 2 x 1)** (4)

8.3 **Specification to conduct cooling system pressure test, check for:**

- Water and anti-freeze ratio. ✓
- Pressure allowed in the radiator. ✓
- Pressure of radiator cap. ✓
- Reading of the cooling system pressure tester. ✓

**(Any 2 x 1)** (2)

8.4 **Safety: Compression test:**

- Ensure that tester can handle the pressure you want it test. ✓
- Clean spark plug area to prevent dirt entering when you remove spark plug. ✓
- Ensure rubber hoses on tester are in good order. ✓
- Ensure release valve on the tester is working. ✓
- Ensure using the right spark plug adaptor. ✓
- Disconnect high tension leads. ✓
- Disconnect the fuel feed. ✓
- Make sure the tester is at zero mark. ✓
- Ensure that the air filter is clean. ✓

**(Any 4 x 1)**. (4)

8.5 **Gas analyser results:**

8.5.1 **High carbon monoxide (CO) reading:**
**Causes:**

- Too rich mixture. ✓
- Ignition misfire. ✓
- Dirty or restricted air filter. ✓
- Improper operation of the fuel delivery system.✓
- Faulty thermostat or coolant sensor. ✓
- Non-functioning PCV valve system. ✓
- Faulty catalytic converter. ✓

**(Any 1 x 1)** (1)

8.5.2 **Corrective measures:**

- Reset fuel mixture. ✓
- Check for misfire and repair. ✓
- Replace air filter. ✓
- Check and correct fuel delivery system. ✓
- Check and repair coolant sensor. ✓
- Check and repair PCV valve. ✓
- Check and repair or replace catalytic converter. ✓

**(Any 1 x 1)** (1)

8.5.3 **Low carbon dioxide ($CO_2$) reading:**
**Causes:**

- Fuel mixture too rich or lean. ✓
- Exhaust system leaks. ✓
- Ignition misfire. ✓
- Dirty or restricted air filter. ✓
- Improper operation of the fuel delivery system.✓
- Faulty thermostat or coolant sensor. ✓
- Non-functioning PCV valve system. ✓
- Faulty catalytic converter. ✓

**(Any 1 x 1)** (1)

8.5.4 **Corrective measures:**

- Reset fuel mixture. ✓
- Repair or replace exhaust system. ✓
- Check for misfire and repair. ✓
- Replace air filter. ✓
- Check and correct fuel delivery system. ✓
- Check and repair coolant sensor. ✓
- Check and repair PCV valve. ✓
- Check and repair or replace catalytic converter. ✓

**(Any 1 x 1)** (1)

8.5.5 **High hydrocarbon (HC) reading:**
**Causes:**

- Excessive unburned fuel by incomplete combustion. ✓
- Improper timing. ✓
- Vacuum leak. (Low fuel pressure) ✓
- Leaking fuel injector. ✓
- Defective cold start valve. ✓
- Faulty air management system. ✓

**(Any 1 x 1)** (1)

8.5.6 **Corrective measures:**

- Reset fuel mixture. ✓
- Check and reset ignition system. ✓
- Check and repair vacuum leaks. ✓
- Check and repair / replace fuel injector. ✓
- Check and repair / replace cold start valve. ✓
- Check and repair air management system. ✓

**(Any 1 x 1)** (1)

8.6 **Specification to conduct fuel pressure test, check for:**

- Fuel pressure before the carburettor. ✓
- Fuel pressure before and after the injector pump. ✓
- Fuel pressure when engine is idling. ✓
- Fuel pressure on high revolutions. ✓

**(Any 2 x 1)** (2)
**[23]**

## QUESTION 9: SYSTEMS AND CONTROL (Automatic gearbox) (Specific)

9.1 **Purpose of an automatic gearbox:**

- To relieve ✓ the driver of clutch and gearshift operation. ✓
- To promote ✓ smoother and easier ✓ driving of the vehicle.

**(Any 1 x 2)** (2)

9.2 **Advantages of vehicle fitted with an automatic gearbox:**

- It reduces driver fatigue. ✓
- It reduces wheel spin under bad road conditions. ✓
- The vehicle can be stopped suddenly without the engine stalling. ✓
- The system dampens all engine torsional vibrations. ✓
- It is easier to drive. (e.g. Disabled persons) ✓

**(Any 2 x 1)** (2)

9.3 **Disadvantages of vehicle fitted with an automatic gearbox:**

- Automatic gearbox is more expensive to manufacture / maintain. ✓
- If a car with automatic gearbox has to be towed for along distance the propeller shaft must be removed. ✓
- Automatic gearbox makes the vehicle heavier that with a manual gearbox. ✓

**(Any 2 x 1)** (2)

9.4 **Torque converter:**

9.4.1 **Labels:**

A – Ring gear / flex plate ✓
B – Casing ✓
C – Stator ✓
D – Impeller / Pump ✓
E – Transmission / Shaft / Spigot ✓
F – Fluid path / Impeller / Pump ✓
G – Vanes ✓
H – Turbine ✓ (8)

9.4.2 **Advantages of torque converter:**

- Torque increases automatically. ✓
- Torque is transferred smoothly to reduce shocks on the gearbox, chassis and wheels. ✓
- Minimum servicing is required. ✓
- Disconnects at low revolutions. ✓

**(Any 2 x 1)** (2)

9.4.3 **Increasing torque converter speed:**

Torque multiplication tapers off ✓ (reduce / decrease) gradually. ✓ (2)

**[18]**

**QUESTION 10: SYSTEMS AND CONTROL (Axles, steering geometry and electronics) (Specific)**

10.1 **Tyre wear:**

10.1.1 **Feathering:**

- Toe-in or toe-out wear ✓
- Worn out king pin ✓

**(Any 1 x 1)** (1)

10.1.2 **One side of the thread worn:**

- Camber wear ✓
- Worn out king pin ✓
- Incorrect wheel alignment ✓

**(Any 1 x 1)** (1)

10.2 **Requirements of well-designed steering mechanism:**

- Light and easy to control. ✓
- Free from vibration and road shocks. ✓
- As direct as possible without needing too much driver attention or effort. ✓
- Self centring. ✓
- Able to operate without being affected by the action of the suspension or braking system. ✓

**(Any 2 x 1)** (2)

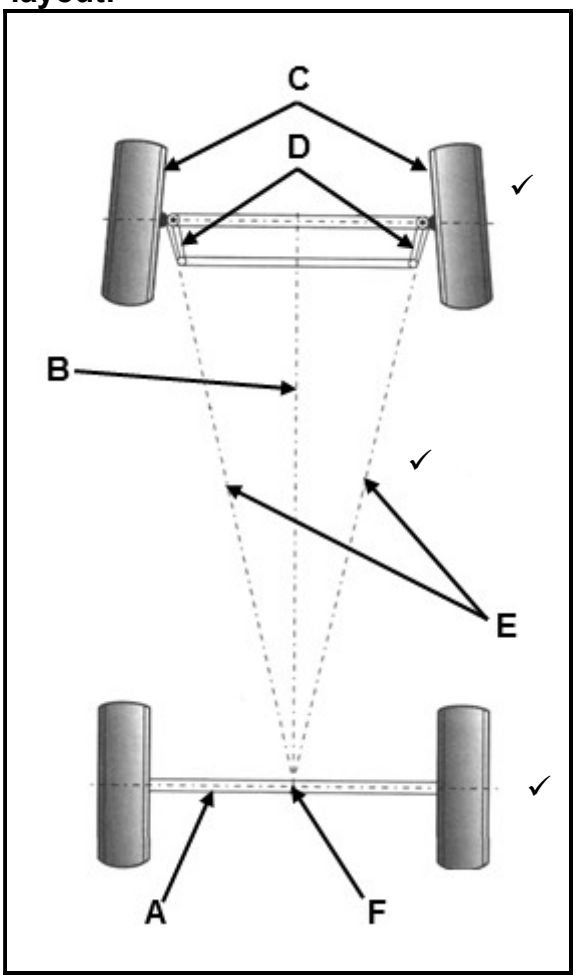
10.3 **King pin inclination:**

10.3.1 **Label:**

A – Offset / Scrub radius / pivot angle radius ✓
B – 90° - Perpendicular ✓
C – Wheel centre line ✓
D – King pin inclination angle ✓
E – Steering axis centre line / King-pin centre line ✓ (5)

10.3.2 King pin inclination is the inward tilt ✓ of the top of the king pin viewed from the front. ✓ (2)

10.4 **Ackerman angle layout:**




(3)

**Labels:**
A – Rear axle ✓
B – Longitudinal axis ✓
C – Front wheels ✓
D – Steering arms ✓
E – Extended centre lines from steering arms ✓
F – Intersection / Centre point ✓

**(Any 3 x 1)** (3)

10.5 **Purpose of Toe-out on turns:**
The toe-out effect in a turn, gives a true rolling motion ✓ to the front wheels in a corner without scuffing. ✓ (2)

10.6 **Wheel balancing pre-checks:**

- The tyres for bruises, cracks and damaged side walls. ✓
- The wheel rims for damaged beads. ✓
- For foreign matter on rim and tyres. ✓
- Tyre pressure. ✓
- Tyre thread wear. ✓

**(Any 2 x 1)** (2)

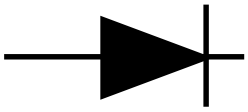
10.7 **Purpose of catalytic convertor:**
The catalytic convertor converts the pollutants ✓ in the exhaust gases of the engine into non – toxic substances making it environmentally friendly. ✓ (2)

10.8 **Adaptive speed control:**
- Maintain a speed as set by the driver. ✓
- Adapt this speed and maintain a safe distance from the vehicle in front. ✓
- Provide a warning if there is a risk of a collision. ✓
- Prevent driver fatigue. ✓
- To control the set speed. ✓
- Improve fuel economy. ✓
- A constant controlled speed setting prevents speeding fines. ✓

**(Any 3 x 1)** (3)

10.9 **Function of slip-ring and brush assembly:**
Provide a moveable connection ✓ in order to allow current flow. ✓ (2)

10.10 **Diode symbol:**



✓✓

(2)

10.11 **Advantages of electric fuel pump:**
- Immediate supply of fuel when the ignition switch is turned on. ✓
- Low operation noise. ✓
- Less discharge pulsation of fuel. ✓
- Compact and lighter design. ✓
- Characterised to prevent fuel leak and vapour lock. ✓
- Delivers fuel at higher pressures. ✓
- Can be placed anywhere in the fuel line. ✓

**(Any 2 x 1)** (2)
**[32]**
**TOTAL: [200]**