basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/
NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: AUTOMOTIVE

MAY/JUNE 2024

MARKS: 200

TIME: 3 hours

This question paper consists of 16 pages and a 2-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the spaces provided on the ANSWER BOOK.

2. Read ALL the questions carefully.

3. Answer ALL the questions.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Start EACH question on a NEW page.

6. Show ALL calculations and units. Round off final answers to TWO decimal places.

7. Candidates may use non-programmable scientific calculators and drawing instruments.

8. The value of gravitational acceleration should be taken as 9,81 m/s^2 or 10 m/s^2.

9. ALL dimensions are in millimetres, unless stated otherwise in the question.

10. Write neatly and legibly.

11. A formula sheet is attached at the end of the question paper.

12. Use the criteria below to assist you in managing your time.

QUESTION	CONTENT	MARKS	TIME IN MINUTES
	GENERIC		
1	Multiple-choice Questions	6	6
2	Safety	10	10
3	Materials	14	14
	SPECIFIC		
4	Multiple-choice Questions	14	10
5	Tools and Equipment	23	20
6	Engines	28	25
7	Forces	32	25
8	Maintenance	23	20
9	Systems and Control (Automatic Gearbox)	18	20
10	Systems and Control (Axles, Steering Geometry and Electronic)	32	30
	TOTAL	**200**	**180**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.6) in the ANSWER BOOK, e.g. 1.7 E.

1.1 Which of the following refers to the Occupational Health and Safety Act (OHSA), 1993 (Act 85 of 1993) when responding to HIV/Aids in the workplace?

  A It is the duty of employers to make sure that rubber gloves and surgical masks are available in all first-aid kits.
  B This Act emphasises the working relationship between employees and employers.
  C It explains the minimum standards that employees and employers can expect from one another in the workplace.
  D The purpose of this Act is to create an environment of equality in the workplace. (1)

1.2 Which ONE of the following statements refers to *process layout*?

  A The machines are arranged in the sequence in which operations are carried out.
  B The different stages of production are carried out in different departments.
  C The process is ideal for mass production.
  D The time period of the manufacturing cycle is shorter. (1)

1.3 What is the function of the pressure gauge in a hydraulic press?

  A To be able to observe the working pressure
  B To support the jig on the platform
  C To stabilise the frame on the support pins
  D To hold the work piece in place (1)

1.4 Why is steel soaked at a specific temperature during heat treatment?

  A To ensure that the outside of the steel becomes hotter than the inside
  B To ensure that the inside of the steel becomes hotter than the outside
  C To prevent a loss in the carbon content of the steel
  D To ensure uniform penetration of heat (1)

1.5 Which ONE of the following quenching media is used for the normalising of steel?

  A Oil
  B Liquid salts
  C Still air
  D Brine (1)

1.6   The metal that is best suited for case-hardening:

        A   Brass
        B   Aluminium
        C   Mild steel
        D   Cast iron   (1)
        [6]
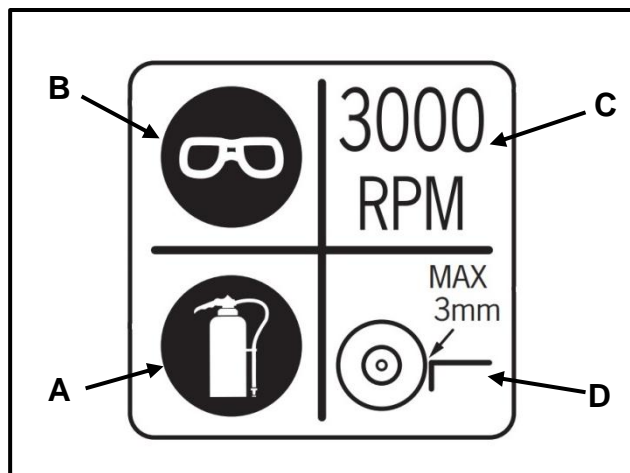
QUESTION 2: SAFETY (GENERIC)

2.1   State TWO situations when basic first aid should be given to help and support a person at the workplace.   (2)

2.2   FIGURE 2.2 below shows a safety sign at a bench grinder. Explain what is meant by the signs labelled **A–D**.

FIGURE 2.2   (4)

2.3   State TWO safety precautions that should be adhered to when using a drill press.

        NOTE: All PPE and environmental factors have been taken care of.   (2)

2.4   State TWO safety precautions that an operator should adhere to while working on a surface grinder.

        NOTE: All PPE and environmental factors have been taken care of.   (2)
   **[10]**

QUESTION 3: MATERIALS (GENERIC)

3.1   State whether steel is heated either *below* or *above* the critical temperature during the following heat-treatment processes:

    3.1.1   Hardening   (1)

    3.1.2   Tempering   (1)

    3.1.3   Normalising   (1)

3.2   The hardness of a sampled work piece is tested using a drill press. Which TWO aspects should be observed on the cutting chips?   (2)

3.3   Besides the machinability test, name THREE other tests used to determine the different types of steels.   (3)

3.4   Name TWO quenching methods used for case-hardening.   (2)

3.5   How can the temperature of a work piece be determined during the heat-treatment process?   (1)

3.6   State the THREE basic steps that are involved in all heat-treatment processes according to a time-temperature cycle.   (3)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (4.1 to 4.14) in the ANSWER BOOK, e.g. 4.15 E.

4.1   What is measured during a compression test?

    A   The compression pressure developed in the cylinder
    B   The amount of leakage from the cylinder in percentage
    C   The amount of exhaust gases leaving the cylinder
    D   The compression ratio developed on the compression stroke   (1)

4.2   When performing wheel alignment, the turntables are used to measure the …

    A   camber angle.
    B   caster angle.
    C   angle at which the wheel is turned left or right.
    D   king pin inclination.   (1)

4.3   What is the function of the waste gate on a turbocharger?

    A   To cool the turbocharger components
    B   Allows the exhaust gases to bypass the turbine
    C   To release excess manifold pressure
    D   Guides exhaust gases onto the turbine   (1)

4.4   Identify the vibration damper shown in FIGURE 4.4 below.
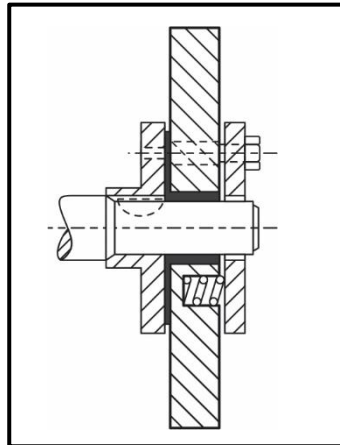
FIGURE 4.4

     A   Combined rubber and friction disc
     B   Flat belt pulley
     C   Flywheel pulley
     D   Friction face   (1)

4.5   When a force overcomes resistance and causes movement in a straight line, it is known as …

     A   power.
     B   torque.
     C   work.
     D   revolutions.   (1)

4.6   Power can be defined as the …

     A   rate at which work is done.
     B   distance over which work is done.
     C   speed at which work is done.
     D   ability to do work.   (1)

4.7   Which ONE of the following is the reason that the mechanical efficiency of an engine is always less than 100%?

     A   A faulty MAF sensor
     B   Frictional loss in the engine
     C   Fuel octane rating that is incorrect
     D   A faulty MAP sensor   (1)

4.8   How can the rated pressure of the radiator cap be obtained?

     A   Read it off the radiator cap
     B   Read it off the intake manifold
     C   Obtain it on the tappet cover
     D   Check it on the pressure tester specifications   (1)

4.9   Excessively high fuel pressure before the fuel injector is caused by …

        A   clogged fuel lines before the fuel filter.
        B   a dirty fuel filter.
        C   a faulty pressure regulator.
        D   low voltage to the fuel pump.   (1)

4.10   Identify the annulus shown in FIGURE 4.10 below.
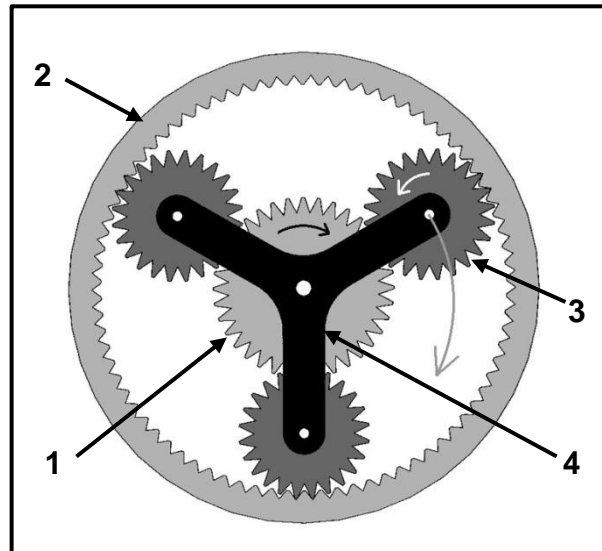
FIGURE 4.10

        A   1
        B   2
        C   3
        D   4   (1)

4.11   Which component of the torque convertor initiates the movement of the turbine shaft?

        A   Turbine
        B   One-way clutch
        C   Pump
        D   Housing   (1)

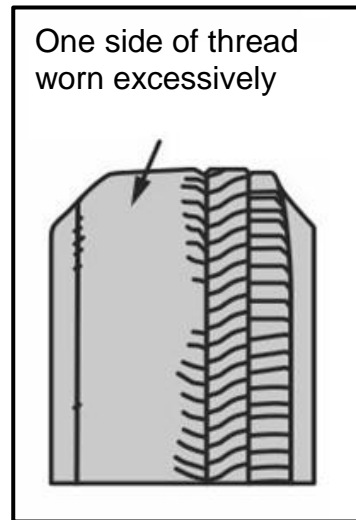4.12   The tyre wear pattern shown in FIGURE 4.12 below is caused by …

One side of thread worn excessively

FIGURE 4.12

    A   incorrect camber.
    B   excessive wheel imbalance.
    C   over-inflated wheel.
    D   underinflated twheel.   (1)

4.13   A sensor can be defined as a/an …

    A   control unit.
   B   input unit.
    C   output unit.
    D   actuator.   (1)

4.14   What is the function of the manifold absolute pressure (MAP) sensor?

    A   Measures the engine load conditions
    B   Controls the position of the throttle
    C   Updates the ECU of the engine speed
    D   Measures the air intake volume   (1)
                                                                [14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

5.1   FIGURE 5.1 below shows a compression tester. Answer the questions that follow.
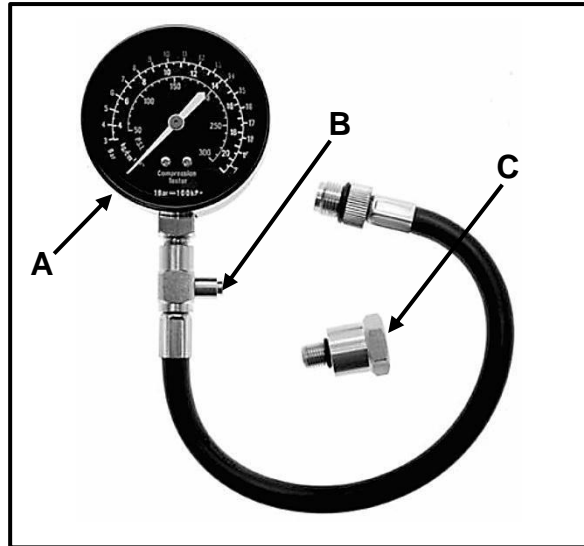
FIGURE 5.1

    5.1.1   State the function of parts **A**, **B** and **C**.   (3)

    5.1.2   Why should the battery voltage be tested before performing a compression test?   (2)

    5.1.3   Give TWO reasons why the wet compression test is performed after the dry compression test.   (2)

5.2   Give a reason why EACH of the following set-up procedures are done during a cylinder leakage test:

    5.2.1   Calibrate (zero) the tester   (1)

    5.2.2   Turn the engine until the piston is at TDC on the compression stroke   (1)

    5.2.3   Lock the crankshaft   (1)

5.3   Name FOUR gases, excluding nitrogen oxide (NOx), that can be analysed by an exhaust gas analyser.   (4)

5.4   A vehicle needs to be scanned using an OBD-II scanner. Answer the questions below.

    5.4.1   State TWO specifications required before an OBD-II scan can be done.   (2)

    5.4.2   State the TWO basic functions of an OBD-II scanner.   (2)

5.5   How is dynamic wheel balancing corrected after the balance is checked on a wheel balancer?   (2)

5.6   FIGURE 5.6 below shows wheel alignment equipment. Answer the questions that follow.
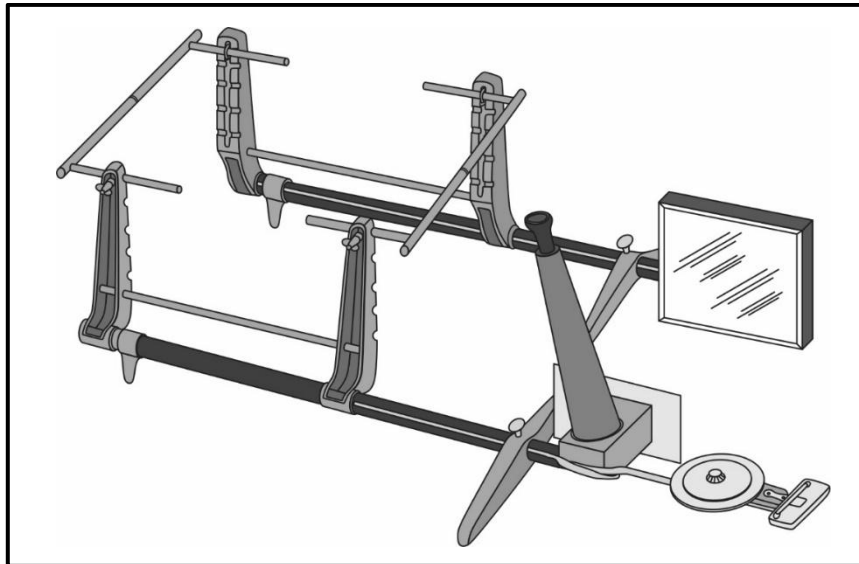
FIGURE 5.6

5.6.1   Identify the specific equipment.   (1)

5.6.2   State the function of the equipment.   (1)

5.6.3   What is the unit of measurement of the equipment?   (1)

[23]

QUESTION 6: ENGINES (SPECIFIC)

6.1   The following questions are based on the crankshaft of an internal combustion engine.

6.1.1   Which component, fitted to the nose of the crankshaft, reduces vibrations?   (1)

6.1.2   Describe TWO ways of modifying crankshaft counterweights to reduce vibrations.   (2)

6.1.3   Which component is bolted around the big-end journal?   (1)

6.1.4   State THREE causes of crankshaft twist during engine operation.   (3)

6.2   Which THREE components are part of the rotating mass on an internal combustion engine?   (3)

6.3   FIGURE 6.3 below shows engine cylinder layouts. Answer the questions that follow.
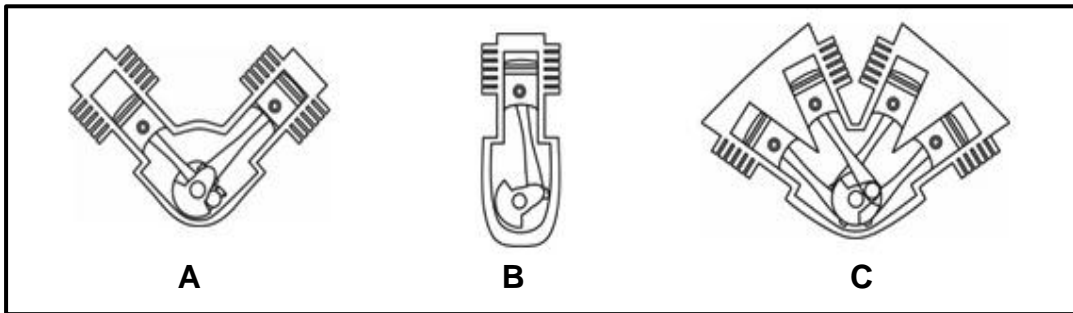

FIGURE 6.3

6.3.1   Identify the different types of engine layouts.   (3)

6.3.2   State TWO advantages of engine layout **A** compared to engine layout **B**.   (2)

6.4   State the degrees of crankshaft rotation between power impulses for EACH of the following four-stroke engines:

6.4.1   Four-cylinder   (1)

6.4.2   Six-cylinder   (1)

6.4.3   Eight-cylinder   (1)

6.5   FIGURE 6.5 below shows a turbocharger that is fitted to an internal combustion engine. Answer the questions that follow.
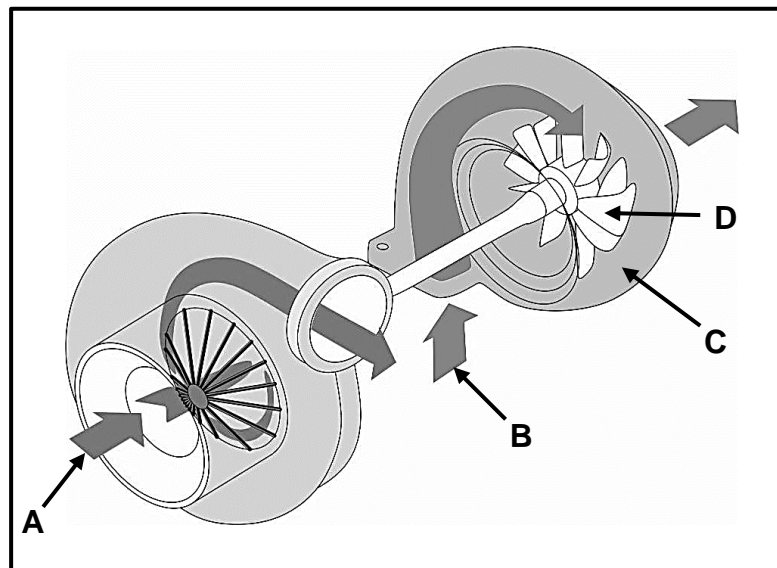

FIGURE 6.5

6.5.1   Label **A–D**.   (4)

6.5.2   Which part in a variable geometry turbocharger helps to speed up the rotation of the turbocharger at low speed?   (1)

6.6   Name THREE types of superchargers used on an internal combustion engine.   (3)

6.7   State TWO disadvantages of superchargers when compared to turbochargers.   (2)

[28]

QUESTION 7: FORCES (SPECIFIC)

7.1   Define the following terms:

     7.1.1   Torque   (2)

     7.1.2   Brake power   (2)

7.2   Explain ONE method of increasing the swept volume of an internal combustion engine.   (1)

7.3   The following measurements were obtained from an internal combustion engine:

     Bore diameter: 74 mm
     Stroke length: 77 mm
     Clearance volume: 42 mℓ

     Calculate the following:

     7.3.1   Swept volume   (3)

     7.3.2   Compression ratio   (4)

     7.3.3   The new stroke length in millimetres (mm) if the compression ratio is increased to 10 **:** 1. The clearance volume and bore diameter remain unchanged.   (6)

7.4   The following data was obtained on a four-cylinder four-stroke engine:

     Mean effective pressure: 950 kPa
     Engine speed: 2 500 r/min
     Bore diameter: 65 mm
     Stroke length: 70 mm
     Brake arm length: 0,4 m
     Scale reading: 142,5 N

     Calculate the following:

     7.4.1   Indicated power in kW   (7)

     7.4.2   Torque   (2)

     7.4.3   Brake power in kW   (3)

     7.4.4   Mechanical efficiency   (2)

[32]

QUESTION 8: MAINTENANCE (SPECIFIC)

8.1   Answer the following questions on the exhaust gas analysis on an internal combustion engine:

         8.1.1   State TWO results of vacuum leaks.   (2)

         8.1.2   State THREE possible causes of a high nitrogen oxide (NOx) reading.   (3)

8.2   TABLE 8.2 below shows the faults, causes and corrective measures of a dry compression test. Complete the table by writing only the question numbers (8.2.1 to 8.2.4) and the answers in the ANSWER BOOK.

FAULTS	POSSIBLE CAUSES	CORRECTIVE MEASURES
Gauge rises in smaller jumps, and compression pressure reading is low	8.2.1	8.2.2
8.2.3	Slipped cambelt	8.2.4

                                      TABLE 8.2   (4)

8.3   A cylinder leakage test shows that air is leaking from the combustion chamber. State where hissing sounds would be heard if air is leaking from/pass the following components:

         8.3.1   Piston rings   (1)

         8.3.2   Intake valve   (1)

         8.3.3   Exhaust valve   (1)

8.4   State THREE manufacturer's specifications required to do an oil pressure test.   (3)

8.5   State TWO causes of a low fuel pressure reading on a fuel pressure tester and give the corrective measure for EACH of the causes.   (4)

8.6   Explain in FOUR steps how to perform a cooling system pressure test after the radiator cap is removed.   (4)

             [23]

QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)

9.1   State THREE advantages of an automatic gearbox fitted with a torque converter. (3)

9.2   FIGURE 9.2 below shows a torque converter used in automatic transmissions. Answer the questions that follow.
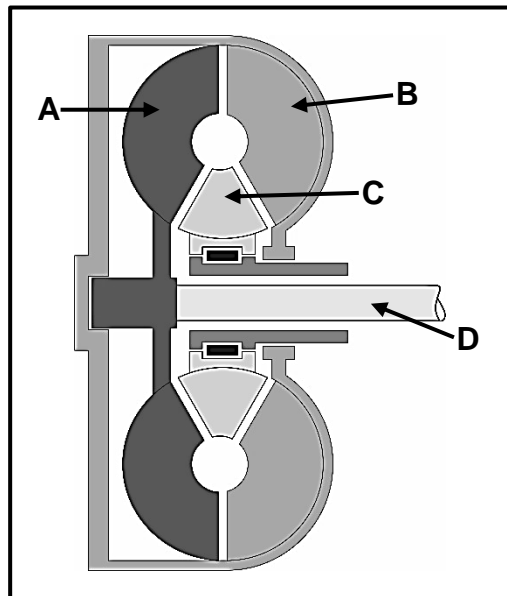
FIGURE 9.2

     9.2.1   Label parts **A**–**D**. (4)

     9.2.2   Define the term *stall speed* in a torque converter. (2)

     9.2.3   Explain what happens when a torque converter stops multiplying torque during driving. (2)

9.3   State TWO advantages of a transmission control unit in an automatic transmission system. (2)

9.4   Describe TWO built-in features used to cool the automatic transmission fluid (ATF) used in a motor vehicle's transmission. (2)

9.5   Explain, in the CORRECT sequence, how forward overdrive is obtained in the double epicyclic gear system. (3)

[18]

QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONICS) (SPECIFIC)

10.1   State TWO improvements that result from correcting the wheel alignment.   (2)

10.2   FIGURE 10.2 below shows an independent front suspension. Answer the questions that follow.
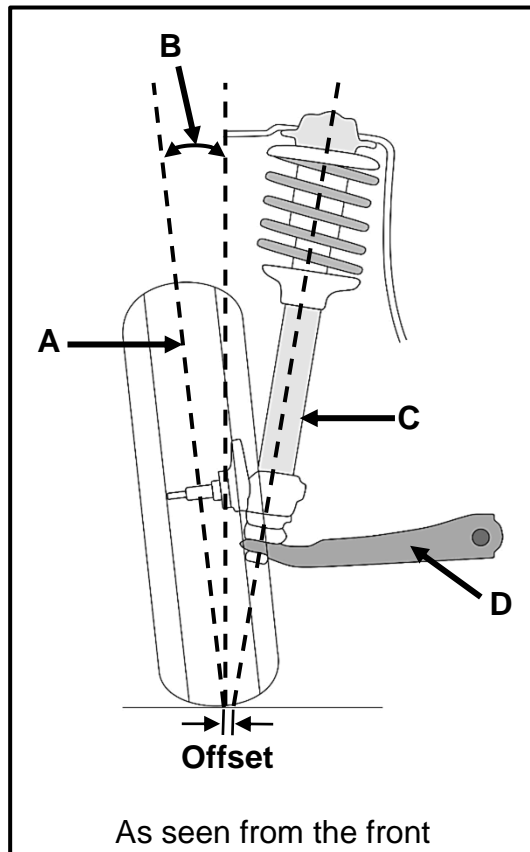
FIGURE 10.2

10.2.1   Label **A–D**.   (4)

10.2.2   How is the camber adjusted on a vehicle?   (1)

10.2.3   State TWO negative effects of excessive positive camber.   (2)

10.3   State THREE pre-checks that must be done on a wheel before dynamic wheel balancing.   (3)

10.4   State TWO functions of each of the following components in the fuel-delivery system:

10.4.1   Pressure regulator   (2)

10.4.2   Fuel pump   (2)

10.5　　State TWO operating conditions that affect ignition timing.　　(2)

10.6　　FIGURE 10.6 below shows a common rail direct injection (CRDI) system. Label **A–D**.
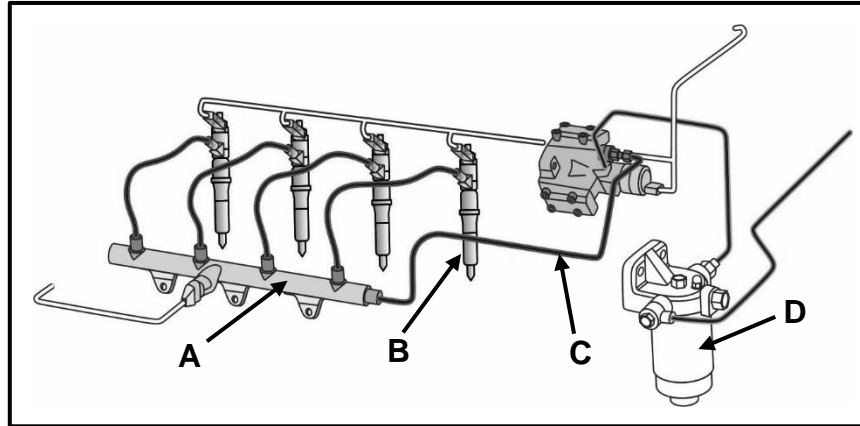

FIGURE 10.6　　(4)

10.7　　State TWO requirements for a catalytic converter to function effectively.　　(2)

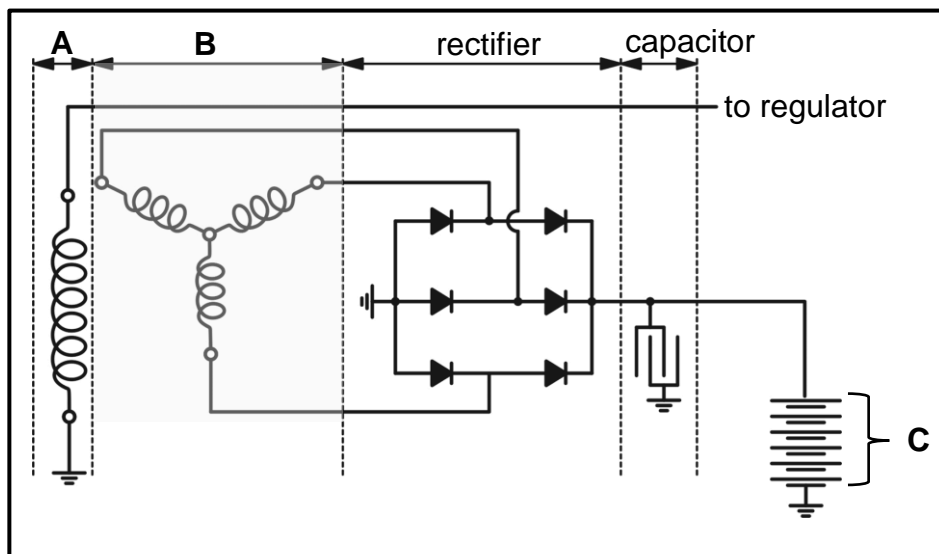10.8　　FIGURE 10.8 below shows a three-phase alternator circuit diagram. Answer the questions that follow.

FIGURE 10.8

10.8.1　　Label components **A–C**.　　(3)

10.8.2　　How many diodes are in this circuit?　　(1)

10.8.3　　State the function of the diodes.　　(2)

10.9　　State TWO methods of deactivating speed control while driving.　　(2)

[32]

TOTAL:　200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY: AUTOMOTIVE

1. $F = m \times a$

   Where:

   $m = Mass$
   $a = Acceleration$

2.   *Work done = Force × Displacement*   *OR* $W = F \times s$

3. $Power = \dfrac{Force \times Displacement}{Time}$ *OR* $P = \dfrac{F \times s}{t}$

4.   *Torque = Force × Radius*   *OR* $T = F \times r$

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

   Where:

   $IP = Indicated\ power$
   $P = Mean\ effective\ pressure$
   $L = Stroke\ length$
   $A = Area\ of\ piston\ crown$
   $N = Number\ of\ power\ strokes\ per\ second$
   $n = Number\ of\ cylinders$

6. $BP = 2\,\pi\,N\,T$

   Where:

   $BP\ =\ Brake\ power$
   $N\ \ =\ Revolutions\ per\ second$
   $T\ \ \ =\ Torque$

7.   *Brake power with Pröny brake* $= 2 \times \pi \times N \times F \times R$

   Where:

   $BP\ =\ Brake\ power$
   $N\ \ =\ Revolutions\ per\ second$
   $F\ \ =\ Force$
   $R\ \ =\ Brake\ arm\ length$

8.   *Mechanical efficiency* $= \dfrac{BP}{IP} \times 100\%$

9.   *Compression ratio* $= \dfrac{SV + CV}{CV}$

     Where:

       SV = Swept volume

       CV = Clearance volume

10. $SV = \dfrac{\pi D^2}{4} \times L$

     Where:

       D = Bore diameter

       L = Stroke length

11. $CV = \dfrac{SV}{CR - 1}$

12.   *Gear ratio* $= \dfrac{Product\ of\ teeth\ on\ driven\ gears}{Product\ of\ teeth\ on\ driver\ gears}$