1. With reference to diesel engine turbochargers:

   (a) explain the reasons why they are fitted; (4)

   (b) sketch an air and gas flow diagram of a pulse type, twin turbocharger, straight six cylinder diesel engine system. (6)

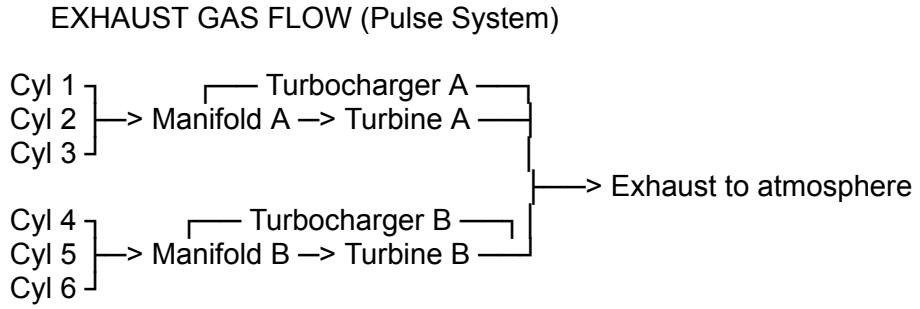
(a)

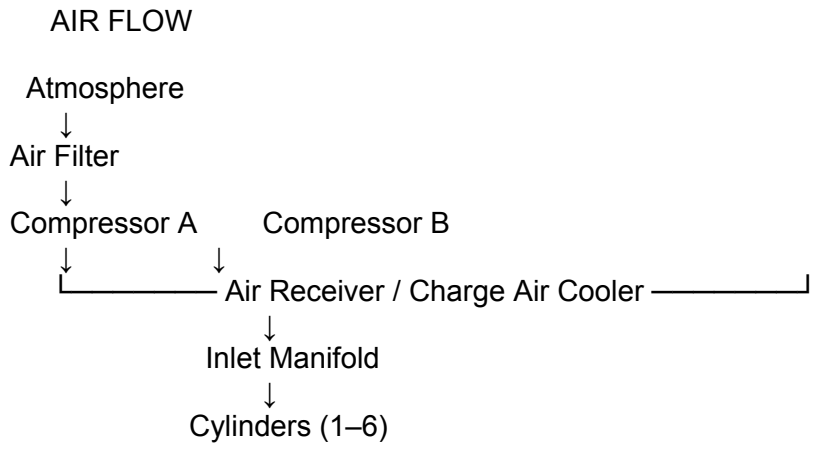
Reasons why turbochargers are fitted (4 marks)

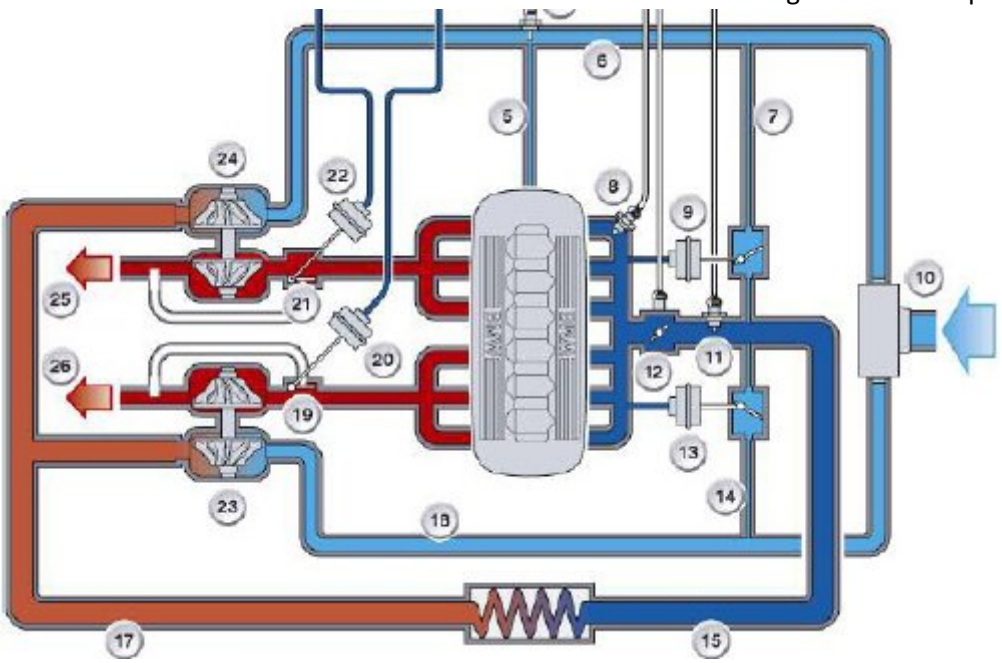
1. **Increase engine power output**
   By forcing more air into the cylinders, more fuel can be burned → higher mean effective pressure → greater power.
2. **Improve fuel efficiency (lower specific fuel consumption)**
   More complete combustion due to better air supply reduces wasted fuel.
3. **Better scavenging of exhaust gases**
   Particularly in two-stroke engines, turbocharging helps remove exhaust gases and fill cylinders with fresh air.
4. **Reduce engine size and weight for a given power**
   A turbocharged engine can produce the same power as a larger naturally aspirated engine.

(b) Air and gas flow diagram (pulse-type, twin turbocharger, straight-six engine) (6 marks)

Below is a simple labelled sketch you could reproduce:







Key points to mention in exam:

- Cylinders divided into **two groups (pulse system)** (e.g. 1–3 and 4–6).
- Each group feeds a **separate turbine** (twin turbocharger setup).
- Exhaust pulses are kept **separate to maximise energy** to turbines.
- Compressors supply air to a **common receiver via intercooler**.
- Air is then distributed to all cylinders.

2. With reference to engine timing belts or chains:

(a) state the cause of loss of timing drive tension; (2)

(b) state how this will affect the engine; (6)

(c) explain how slight loss of tension can be corrected. (2)

(a)

Cause of loss of timing drive tension (2 marks)

1. **Wear and elongation of the belt/chain** (stretching over time).
2. **Failure or weakening of the tensioner** (spring/hydraulic tensioner losing effectiveness).

(b) Effect on the engine (6 marks)

1. **Incorrect valve timing**
   Camshaft timing shifts relative to the crankshaft.
2. **Poor engine performance**
   Reduced power and efficiency due to improper air/fuel exchange.
3. **Misfiring or rough running**
   Valves opening/closing at the wrong time disrupt combustion.
4. **Increased fuel consumption**
   Inefficient combustion leads to higher fuel usage.
5. **Abnormal noise**
   Slapping or rattling from loose chain/belt.
6. **Risk of severe engine damage**
   In interference engines, valves may contact pistons → bent valves, piston damage.

(c) Correction of slight loss of tension (2 marks)

1. **Adjust or reset the tensioner** (manual or automatic type).
2. **Take up slack by repositioning or tightening the belt/chain** (or replacing if worn).

3. Describe a procedure for manually testing the set points on diesel generator HT cooling water, high temperature alarm and shut down. (10)

Procedure for manually testing HT cooling water high temperature alarm and shutdown

1. Preparation and safety precautions

- Inform bridge and engine room personnel of the test.
- Obtain permission and ensure the test will not endanger the vessel.
- Check engine is at a **safe load or on standby generator** if possible.
- Ensure **override arrangements** are available (for shutdown trip if required).
- Confirm correct **set points** from manufacturer's data.

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2. Identify temperature sensor and control system

- Locate the **HT cooling water temperature sensor** (usually at engine outlet).
- Identify associated **alarm and shutdown devices** in the control system.

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3. Simulate temperature increase (manual testing)

One of the following methods may be used:

- **Electrical simulation:**
  Disconnect sensor and apply a **variable resistance/decade box** to simulate rising temperature.
- **Local heating method:**
  Carefully apply heat (e.g. warm water or heat source) to the sensor (if permitted).
- **Adjustment method:**
  Gradually **raise the controller set point** to simulate alarm condition.

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4. Check high temperature alarm operation

- Slowly increase simulated temperature.
- Verify that:
  - Alarm activates at the **correct set point**.
  - Audible and visual alarms function properly.
  - Alarm is correctly displayed in control room.

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5. Check shutdown (trip) operation

- Continue increasing temperature simulation.

- Confirm:
  - Shutdown activates at the **preset higher limit**.
  - Engine stops or trips as designed.
  - Shutdown signal is correctly indicated.

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6. Reset and restore system

- Reset alarms and shutdown systems.
- Reconnect sensor and return controls to normal settings.
- Restart engine if stopped and check normal operation.

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7. Final checks and documentation

- Confirm system is fully operational.
- Record results in the **engine room logbook**.
- Report any discrepancies and adjust/calibrate if necessary.

Key points examiners look for:

- Safe working + communication
- Method of simulation (very important)
- Separate checking of **alarm and shutdown set points**
- Reset and documentation

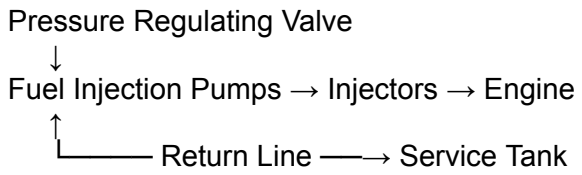
Paragraph answer

To manually test the set points of a diesel generator HT cooling water high temperature alarm and shutdown, permission must first be obtained and all relevant personnel informed to ensure safe operation. The engine should be operating at a safe load or on standby, and manufacturer's set points confirmed. The HT temperature sensor, typically located at the engine outlet, is then identified and a temperature rise is simulated, either by disconnecting the sensor and applying a variable resistance, carefully heating the sensor if permitted, or adjusting the controller input. The simulated temperature is gradually increased and the high temperature alarm is checked to ensure it activates at the correct set point with proper audible and visual indications. The temperature is then further increased to verify that the shutdown operates at its designated higher set point, stopping the engine as intended. After testing, the system is reset, all connections restored, and normal settings reinstated. The engine is returned to normal operation, and the results of the test are recorded in the engine room logbook, with any faults reported and rectified.

4. Describe, with the aid of a sketch, a typical distillate fuel supply system for a diesel engine, including ALL the safety devices. (10)

Sketch of a typical distillate fuel oil system (diesel engine)

Storage Tank
↓
Transfer Pump
↓
Settling Tank
↓
Service Tank (Day Tank)
↓
Supply Pump ⟶ Duplex Filter ⟶ Final Filter
↓



(Overflow from Service Tank → Storage Tank)

Description (including ALL safety devices)

A typical distillate fuel system begins with fuel stored in **storage tanks**, from which it is transferred by a transfer pump to a **settling tank**, allowing water and impurities to separate. Fuel then flows to a **service (day) tank**, which supplies clean fuel to the engine.

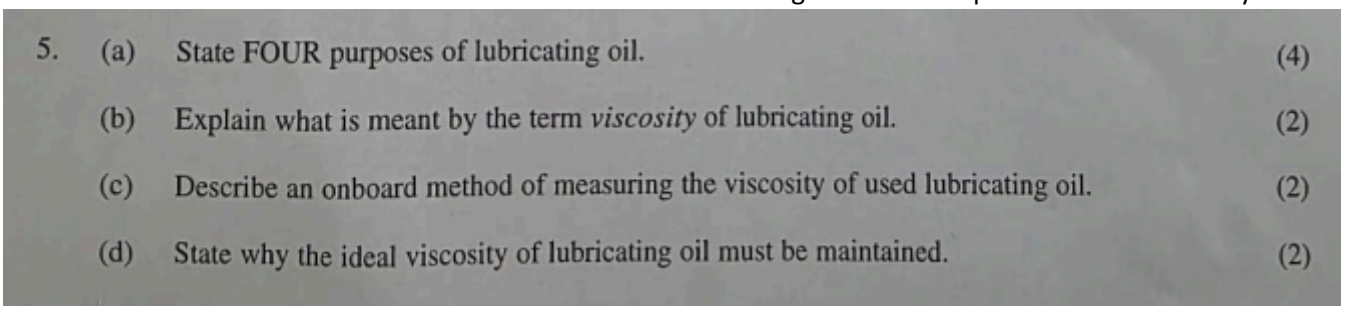
From the service tank, a **supply pump** delivers fuel through a **duplex filter** (allowing changeover without stopping flow) and then a **fine/final filter** to ensure cleanliness before entering the engine. A **pressure regulating valve** maintains correct fuel pressure by returning excess fuel to the suction side or service tank. Fuel is then supplied to the **fuel injection pumps**, which deliver it at high pressure to the injectors for combustion. Excess fuel returns via a **return line** to the service tank.

Safety devices (must be clearly stated for full marks)

- **Quick closing valves (QCVs)** on storage and service tanks
  → Allow remote shut-off in case of fire.
- **Overflow pipe (service tank to storage tank)**
  → Prevents overfilling and spillage.
- **Air vent pipes with flame screens**
  → Prevent pressure build-up and stop flame ingress.
- **High and low level alarms on service tank**
  → Prevent overflow and fuel starvation.
- **Relief valve on fuel supply pump/system**
  → Protects system from overpressure.
- **Duplex filters with pressure differential indicator**
  → Allows safe changeover and indicates blockage.
- **Leak-off / drain arrangements**
  → Safe handling of fuel leakage.
- **Thermometers and pressure gauges**
  → Monitoring for safe operation.
- **Remote stop for pumps**
  → Emergency shutdown capability.

Key exam tips:

- Clearly show **flow from storage → engine → return**
- Include **at least 5–6 safety devices**
- Label sketch neatly (even a simple block diagram scores marks)



5. (a) State FOUR purposes of lubricating oil. (4)

(b) Explain what is meant by the term *viscosity* of lubricating oil. (2)

(c) Describe an onboard method of measuring the viscosity of used lubricating oil. (2)

(d) State why the ideal viscosity of lubricating oil must be maintained. (2)

(a)

State FOUR purposes of lubricating oil (4 marks)

1. **Reduce friction and wear** between moving parts.
2. **Cool components** by carrying away heat.
3. **Clean the engine** by suspending and removing contaminants.
4. **Provide sealing** between piston rings and cylinder liner.

(Other acceptable: corrosion protection, shock absorption)

(b) Explain viscosity of lubricating oil (2 marks)

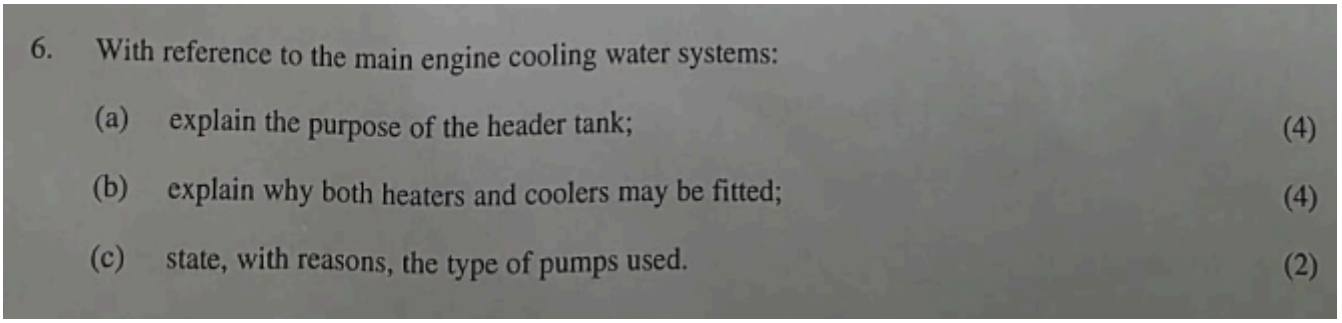
Viscosity is the **measure of a fluid's resistance to flow**, or its internal friction. A high-viscosity oil is thicker and flows more slowly, while a low-viscosity oil is thinner and flows more easily.

(c) Onboard method of measuring viscosity (2 marks)

Viscosity can be measured using a **viscometer** (e.g. Redwood or similar), where the **time taken for a fixed volume of oil to flow through a standard orifice at a controlled temperature** is recorded and used to determine viscosity.

(d) Why ideal viscosity must be maintained (2 marks)

- To ensure an **adequate lubricating film** is maintained, preventing metal-to-metal contact.
- To avoid **excessive friction or poor circulation**, which can lead to overheating, wear, and possible engine damage.



6. With reference to the main engine cooling water systems:

(a) explain the purpose of the header tank; (4)

(b) explain why both heaters and coolers may be fitted; (4)

(c) state, with reasons, the type of pumps used. (2)

(a)

Purpose of the header tank (4 marks)

- **Maintains a constant static head** of water in the system to ensure positive pressure.
- **Allows for thermal expansion and contraction** of the cooling water.
- **Provides a make-up source** to compensate for minor losses or leaks.
- **Acts as a venting point** to remove air and prevent air locks in the system.

(b) Why both heaters and coolers may be fitted (4 marks)

- **Coolers** are used to remove excess heat from the engine and maintain the cooling water at the correct operating temperature.
- **Heaters** are fitted to:
  - Keep the engine warm when stopped (prevent thermal shock during start-up).
  - Maintain correct viscosity of lubricating oil and proper clearances.
- Together, they ensure the engine operates within an **optimal temperature range under all conditions** (start-up, low load, full load).

(c) Type of pumps used, with reasons (2 marks)

- **Centrifugal pumps** are used because they:
  - Provide a **continuous, smooth flow** of cooling water.
  - Are **simple, reliable, and suitable for large flow rates** required in cooling systems.

7. With reference to plate type heat exchangers:

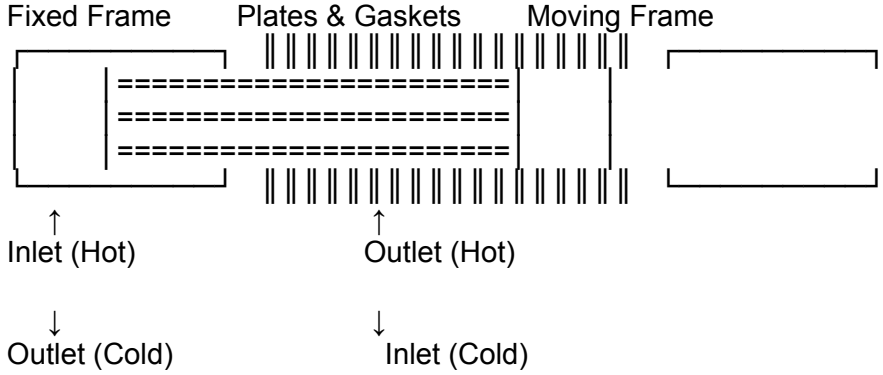
(a) sketch the assembly, labelling the main components and indicating the direction of flow; (5)

(b) state the materials used for the plates and seals; (2)

(c) state the purpose of the plates being corrugated; (2)

(d) state the purpose of *tell tales*. (1)

a) Sketch of a plate type heat exchanger (5 marks)



Labels to include:

- Fixed frame plate
- Moving frame plate
- Tie bolts / tightening bolts
- Corrugated plates
- Gaskets (seals)
- Inlet and outlet ports
- Flow direction (counterflow preferred)

(b) Materials used (2 marks)

- **Plates:** Stainless steel (commonly), sometimes titanium (for seawater).
- **Seals (gaskets):** Rubber materials such as nitrile (NBR) or EPDM.

(c) Purpose of corrugated plates (2 marks)

- Increase **surface area** for better heat transfer.
- Promote **turbulence**, improving heat exchange efficiency and reducing fouling.

(d) Purpose of tell-tales (1 mark)

- To **detect leakage between fluids** by allowing any leaking fluid to escape externally, preventing mixing of the two fluids.

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8. (a) Explain why a diesel engine may fail to run when turned by the starting mechanism. (6)

   (b) Explain the procedure to be adopted in order to solve the problem in part (a). (4)

(a) Reasons why a diesel engine may fail to run when turned (6 marks)

1. **No fuel or insufficient fuel supply**
   (Empty tank, blocked filters, air in fuel system).
2. **Poor fuel injection**
   (Faulty injectors, incorrect timing, low injection pressure).
3. **Insufficient compression**
   (Worn piston rings, leaking valves, cylinder wear).
4. **Starting system issues**
   (Low starting air pressure, faulty starter motor, air distributor fault).
5. **Incorrect valve timing**
   (Timing gear fault, slipped chain/belt).
6. **Fuel not igniting properly**
   (Low temperature, poor atomisation, incorrect fuel quality).

(b) Procedure to solve the problem (4 marks)

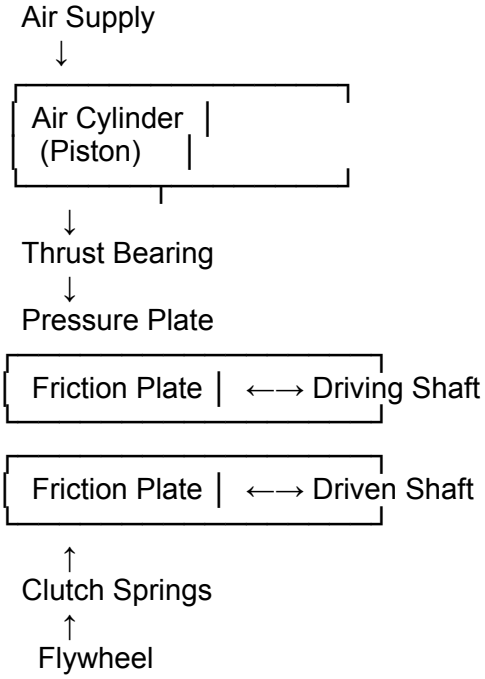
1. **Check fuel system**
   - Ensure fuel is available and valves are open.
   - Check and clean filters, bleed air from system.
2. **Check starting system**
   - Verify starting air pressure or battery condition.
   - Inspect starter mechanism and controls.
3. **Check injection and timing**
   - Inspect injectors and fuel pumps.
   - Confirm correct timing of fuel injection and valves.
4. **Check compression and engine condition**

- Look for signs of leakage, worn components, or abnormal operation.

9. (a) Sketch a pneumatically operated friction clutch, labelling all parts. (7)

(b) State how the clutch sketched in part (a) may be operated in the event of air failure. (3)

(a) Pneumatically operated friction clutch (7 marks)



Labels to include:

- Air inlet / control valve
- Air cylinder and piston
- Thrust bearing
- Pressure plate
- Friction plates (driving and driven)
- Clutch springs
- Flywheel / driving member
- Output (driven shaft)

Description:

Compressed air enters the **air cylinder**, forcing the piston forward. This movement is transmitted through a **thrust bearing** to the **pressure plate**, compressing the **friction plates** together. The friction transmits torque from the driving shaft (engine/flywheel) to the driven shaft. When air is released, **springs disengage the clutch**.

(b) Operation in the event of air failure (3 marks)

- The clutch can be **manually operated** using a **mechanical screw or lever arrangement**.
- Springs or mechanical linkage allow **manual engagement/disengagement**.
- Some systems are designed to **fail-safe (disengaged or engaged)** depending on application.

10. With reference to reduction gears, state the advantages and disadvantages of EACH of the following:

(a) helical teeth compared with spur teeth; (5)

(b) double helix compared to single helix. (5)

(a) Helical teeth compared with spur teeth (5 marks)

Advantages of helical gears:

- **Smoother and quieter operation** due to gradual engagement of teeth.
- **Higher load carrying capacity** (more than one tooth in contact at a time).
- **Less vibration and shock loading**.

Disadvantages:

- **Axial (thrust) force is produced**, requiring thrust bearings.
- **More complex and expensive to manufacture**.
- Slightly **lower efficiency** due to sliding action between teeth.

(b) Double helical compared to single helical (5 marks)

Advantages of double helical gears:

- **Eliminates axial thrust** (opposing helices cancel thrust forces).
- **Smoother power transmission** than single helical.
- **Higher load capacity and better balance**.

Disadvantages:

- **More complex and expensive to manufacture**.
- **Alignment is more critical**.
- Larger and heavier construction.