1. Explain the effects of EACH of the following:

(a) early ignition; (4)

(b) late ignition; (4)

(c) low compression. (2)

(a)

Early ignition (4 marks)

- Combustion starts **before the correct timing point (before TDC)**.
- Causes **very high peak pressures and temperatures**.
- Leads to **knocking/diesel knock** and rough running.
- Results in **increased mechanical stress and possible engine damage**.

(b) Late ignition (4 marks)

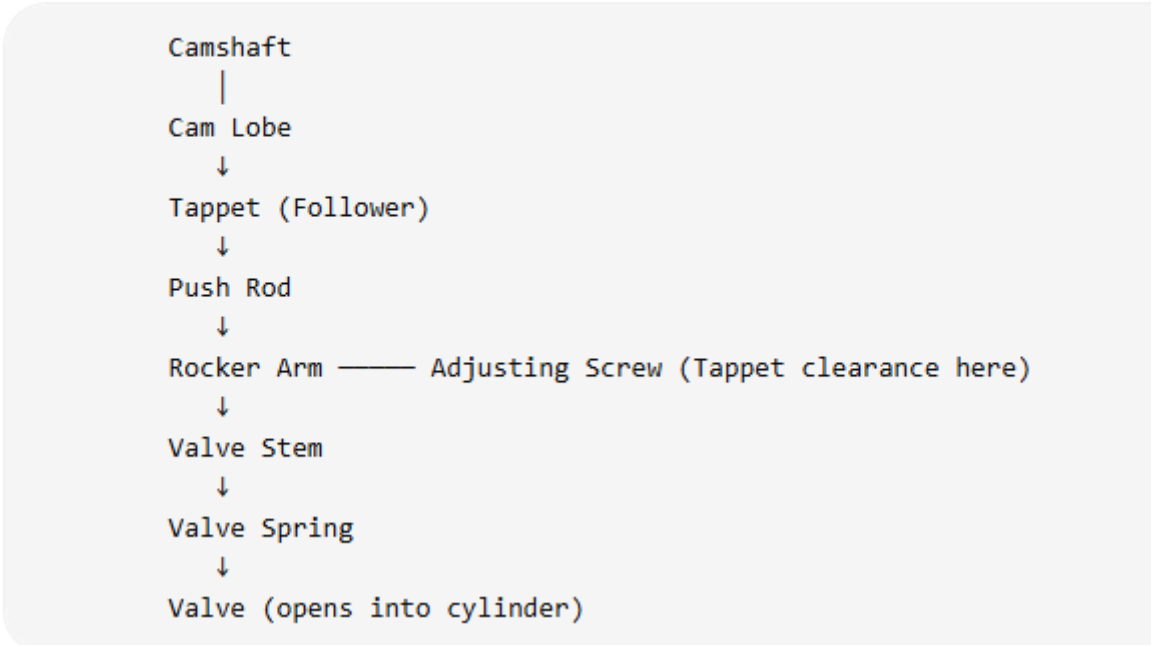
- Combustion occurs **after the correct timing point (after TDC)**.
- Leads to **reduced power output** (less effective expansion).
- Causes **high exhaust gas temperatures**.
- Results in **poor fuel efficiency and possible smoke** due to incomplete combustion.

(c) Low compression (2 marks)

- Produces **low air temperature at end of compression**.
- Causes **poor or delayed ignition**, leading to difficult starting and loss of power.

2. Describe, with the aid of a sketch, a valve actuating mechanism for a 4-stroke engine from cam to valve, labelling the MAIN components and showing where the tappet clearance may be measured. (10)

(a) Valve actuating mechanism (cam to valve) (10 marks)



Main components to label:

- Camshaft
- Cam lobe
- Tappet (cam follower)
- Push rod
- Rocker arm
- Adjusting screw and locknut
- Valve stem
- Valve spring
- Valve (inlet or exhaust)

Description:

The camshaft, driven by the crankshaft, rotates and its **cam lobe** lifts the **tappet (follower)**. This upward motion is transmitted through the **push rod** to the **rocker arm**, which pivots and pushes down on the **valve stem**, opening the valve against the **valve spring**. When the cam rotates away, the spring closes the valve, returning all components to their original position.

Tappet clearance (important for marks):

- The **tappet clearance (valve clearance)** is the small gap between the **rocker arm adjusting screw and the valve stem tip**.
- It is measured using a **feeler gauge** when the valve is closed (cam on base circle).
- This clearance allows for **thermal expansion** and ensures proper valve operation.

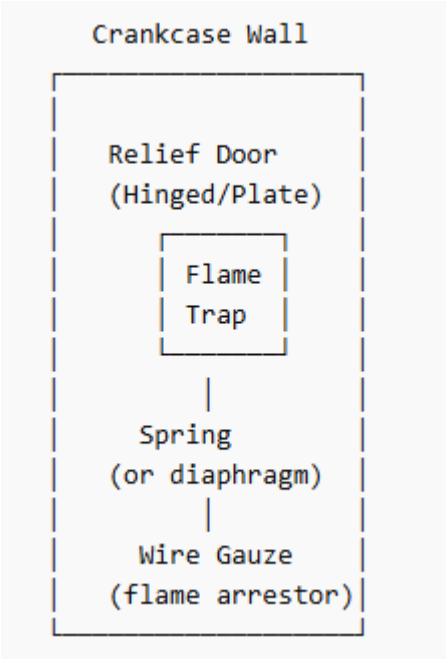
3. (a) Outline the actions which must be taken, by the on-watch engineer when the engine crankcase oil mist detector activates. (5)

(b) Sketch a crankcase explosion relief door, labelling the MAIN components. (5)

(a) Actions when crankcase oil mist detector activates (5 marks)

1. **Immediately reduce engine speed/load**
   → Minimises heat generation and risk of ignition.
2. **Stop the engine as soon as it is safe to do so**
   → Prevents escalation to crankcase explosion.
3. **Do NOT open crankcase doors immediately**
   → Risk of air ingress causing explosion.
4. **Shut off fuel supply and isolate engine**
   → Prevent further operation.
5. **Allow sufficient cooling time**
   → Then carefully inspect for hot spots, bearing failure, or mechanical damage.

(b) Crankcase explosion relief door (5 marks)



Main components to label:

- Relief door / valve plate
- Spring or diaphragm (holds door closed)
- Flame trap (wire gauze)
- Crankcase casing
- Hinges or securing arrangement

Description:

The crankcase relief door is designed to **relieve excess pressure** caused by a crankcase explosion. When pressure rises suddenly, the **spring-loaded door lifts**, allowing gases to escape. The escaping gases pass through a **flame trap (wire gauze)**, which cools and extinguishes flames, preventing fire from spreading outside the crankcase. Once pressure is relieved, the door reseats to maintain crankcase integrity.

4. With reference to scroll type fuel injection pumps:

(a) describe how the delivered quantity of fuel may be varied; (5)

(b) explain the purpose of the delivery valve; (3)

(c) describe how fuel oil is prevented from spraying out if the high pressure pipe fails in service. (2)

(a) How delivered quantity of fuel is varied (5 marks)

In a scroll (helix) type fuel injection pump, the quantity of fuel delivered is controlled by **rotating the plunger**, which has a **helical groove (scroll)**. As the plunger rises, it initially closes the spill port and fuel is delivered under pressure. When the helix aligns with the spill port, the pressure is released and injection stops. By rotating the plunger using the **control rack**, the position at which the helix uncovers the spill port is changed. This alters the **effective stroke** of the plunger and therefore the **amount of fuel delivered**—earlier spill gives less fuel, later spill gives more fuel.

(b) Purpose of the delivery valve (3 marks)

- Prevents **backflow of fuel** from the high-pressure line to the pump.
- Ensures a **sharp cut-off** of fuel injection.
- Maintains **residual pressure in the fuel line**, improving injection quality and preventing dribble.

(c) How fuel spray is prevented if HP pipe fails (2 marks)

- A **double-skinned (jacketed) high-pressure pipe** is used.
- Any leaking fuel is **contained within the outer pipe and drained safely**, preventing spraying and fire risk.

5. With reference to distillate fuel oil material safety datasheets, describe with examples the information that would be included for EACH of the following:

(a) hazards; (4)

(b) first aid; (3)

(c) fire fighting measures. (3)

(a) Hazards (4 marks)

Material Safety Data Sheets (MSDS) for distillate fuel oil list hazards such as:

- **Flammability** → fuel can ignite easily when exposed to heat or sparks.
- **Health hazards** → skin irritation or dermatitis from prolonged contact.
- **Inhalation risks** → vapours may cause dizziness, headaches, or respiratory irritation.
- **Environmental hazards** → harmful to marine life if spilled.

(b) First aid (3 marks)

- **Skin contact** → wash immediately with soap and water.
- **Eye contact** → rinse thoroughly with clean water for several minutes.
- **Inhalation** → move person to fresh air and seek medical attention if symptoms persist.

(c) Fire fighting measures (3 marks)

- Use **foam, dry powder, or CO_2 extinguishers**.
- **Do not use water jets** (may spread the fire).
- Cool surrounding areas with water spray to prevent spread and re-ignition.

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6. (a) Describe how contamination of fuel oil by EACH of the following can occur:

   (i) microbes; (2)

   (ii) sodium chloride. (2)

   (b) Describe how to avoid fuel system and engine related problems with reference to the TWO contaminants in part (a). (6)

(a) How contamination can occur (4 marks)

(i) Microbes (2 marks)

- Occur when **water is present in the fuel**, providing a medium for microbial growth.
- Contamination may enter via **condensation in tanks**, contaminated bunkers, or poor storage conditions.

(ii) Sodium chloride (2 marks)

- Enters fuel through **seawater contamination**, often due to **leaks in storage tanks**, pipelines, or during bunkering.
- Can also result from **contaminated supply from shore or barge**.

(b) Avoiding fuel system and engine problems (6 marks)

For microbial contamination:

- **Regularly drain water** from tanks to remove the medium for growth.
- Use **biocides** to kill microorganisms.
- Maintain good **tank hygiene and cleanliness**.

For sodium chloride contamination:

- **Prevent seawater ingress** by maintaining tank and pipeline integrity.
- **Test fuel before and during bunkering**.
- Use **purification (centrifuges)** to remove water and salts.

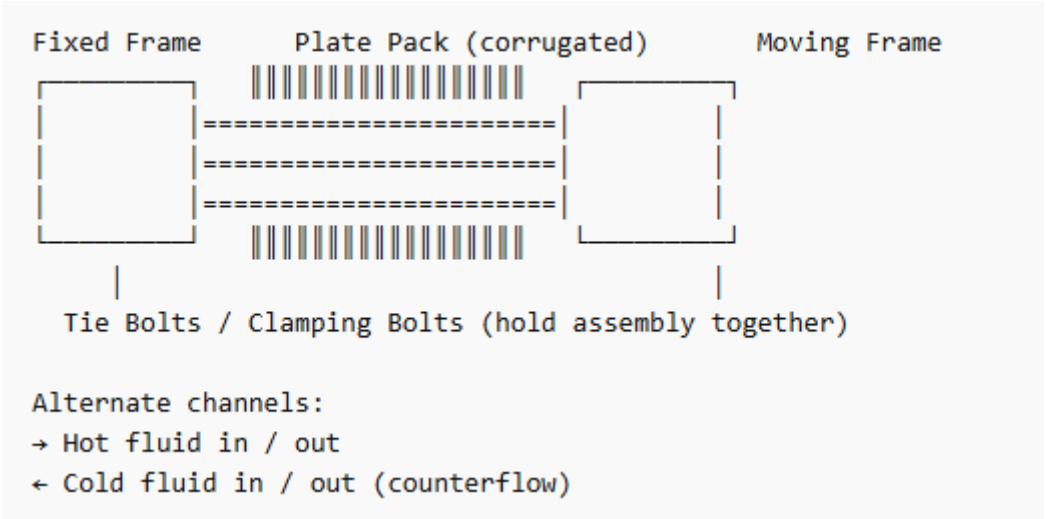
General measures:

- Regular **sampling and monitoring** of fuel quality.
- Maintain **efficient filtration and separation systems**.

7. (a) Describe, with the aid of a sketch, the construction of a plate type heat exchanger. (7)

(b) State THREE advantages of the plate types, compared with the tube type heat exchanger. (3)

(a) Construction of a plate type heat exchanger (7 marks)



Description:

A plate type heat exchanger consists of a series of **thin, corrugated metal plates** clamped together between a **fixed frame** and a **movable frame** using **tie bolts**. Each plate is fitted with **gaskets**, which seal the edges and direct fluids into **alternate channels**.

The hot and cold fluids flow in **separate alternating passages**, usually in **counterflow**, allowing efficient heat transfer through the plate surfaces. The **corrugations** increase surface area and create turbulence, improving heat transfer efficiency. Ports in the plates allow fluid entry and exit, while the gasket arrangement prevents mixing of fluids.

(b) THREE advantages over tube type heat exchanger (3 marks)

1. **Higher heat transfer efficiency** due to turbulence and large surface area.
2. **Compact and lightweight design** (less space required).
3. **Easy maintenance and cleaning** (plates can be dismantled and cleaned individually).

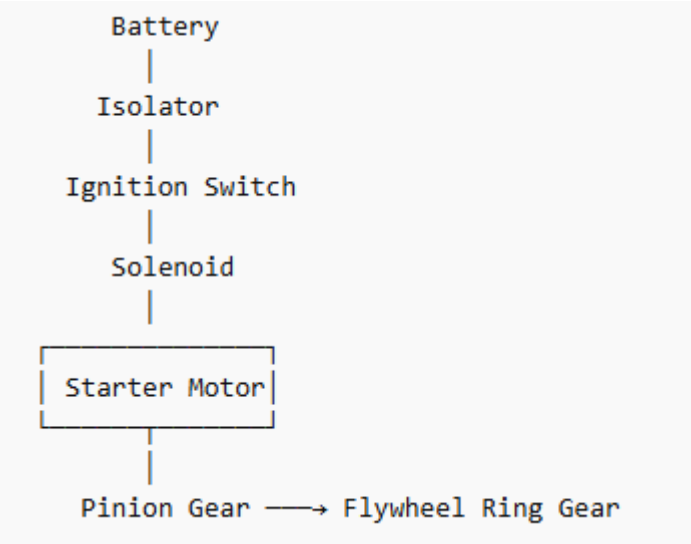
8. (a) Sketch an electric starting motor system, labelling the MAIN components. (5)

(b) With reference to the starting system batteries in part (a):

(i) describe the maintenance checks required to prolong the batteries life; (3)

(ii) describe any safety procedures necessary when handling batteries. (2)

(a) Electric starting motor system (5 marks)



Main components to label:

- Battery
- Isolator switch
- Ignition/start switch
- Solenoid
- Starter motor
- Pinion gear
- Flywheel ring gear

(b) (i) Maintenance checks to prolong battery life (3 marks)

- **Check electrolyte level** and top up with distilled water if required.
- **Clean terminals and ensure tight connections** to prevent resistance and corrosion.
- **Check state of charge/specific gravity** regularly and ensure proper charging.

(b) (ii) Safety procedures when handling batteries (2 marks)

- Wear **protective equipment** (gloves and eye protection) to avoid acid contact.
- Ensure **good ventilation and no sparks/flames**, as hydrogen gas may be present.

9. (a) State the safety precautions necessary before removing a four stroke diesel engine cylinder head. (4)

(b) Explain the procedure for removing a four stroke diesel engine cylinder head. (6)

(a) Safety precautions before removing a four-stroke diesel engine cylinder head (4 marks)

- **Shut down and isolate the engine** (fuel, starting air, electrical systems).
- Ensure engine is **cool and depressurised** (no hot surfaces or pressure).
- **Lock out and tag out** controls to prevent accidental starting.
- Wear appropriate **PPE** (gloves, helmet, eye protection) and ensure proper lifting equipment is ready.

(b) Procedure for removing a four-stroke diesel engine cylinder head (6 marks)

1. **Drain cooling water** from the cylinder head and disconnect associated pipework.
2. **Remove fuel pipes and injector connections**, ensuring cleanliness to avoid contamination.
3. **Disconnect valve gear components** (rocker arms, push rods, etc.).
4. **Remove cylinder head securing nuts/bolts** in the correct sequence to avoid distortion.
5. Attach **lifting gear** and carefully lift the cylinder head clear of the engine.
6. Place the head on a suitable support and **inspect gasket surfaces and components**.

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10. (a) State how gearbox oil may become contaminated with water. (1)

    (b) Explain the effects of water contamination of gearbox oil. (5)

    (c) Describe the actions to be taken should a gearbox become contaminated with water. (4)

(a) How gearbox oil may become contaminated with water (1 mark)

- **Leakage from a cooler** (e.g. oil cooler tube failure allowing water ingress).

(b) Effects of water contamination of gearbox oil (5 marks)

1. **Loss of lubricating properties** → reduced film strength.
2. **Increased wear of gears and bearings** due to metal-to-metal contact.
3. **Corrosion and rusting** of internal components.
4. **Formation of emulsions (milky oil)** reducing effectiveness.
5. **Overheating and possible gear failure** due to poor lubrication.

(c) Actions to be taken (4 marks)

1. **Stop or reduce load on the gearbox** to prevent damage.
2. **Identify and repair the source of water ingress** (e.g. cooler leak).
3. **Drain contaminated oil and flush the system**.
4. **Refill with clean oil and monitor condition** (check for further contamination).