1. State TEN routine watchkeeping duties to be carried out by the duty watchkeeping engineer. (10)

1. State TEN routine watchkeeping duties to be carried out by the duty watchkeeping engineer. (10 marks)

The duty watchkeeping engineer is responsible for the safe and efficient operation of all machinery during the watch. Routine duties include the following:

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1. Monitor Main Propulsion Machinery

- Check the operation of the main engine and associated systems.
- Observe pressures, temperatures, speeds, and vibration levels.

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2. Inspect Auxiliary Machinery

- Regularly inspect generators, boilers, air compressors, purifiers, pumps, refrigeration plants, and steering gear machinery.

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3. Maintain Correct Lubricating Oil Levels

- Check sump levels and service tanks.
- Ensure lubricating oil pressures and temperatures remain within normal limits.

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4. Monitor Cooling Water Systems

- Check jacket water temperatures and pressures.
- Monitor seawater and freshwater cooling systems for correct operation.

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5. Check Fuel Oil Systems

- Verify fuel service tank levels.
- Check fuel temperatures, pressures, filters, and transfer arrangements.

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6. Make Engine Room Log Book Entries

- Record machinery readings at the required intervals.
- Enter temperatures, pressures, tank levels, running hours, and any abnormalities.

---

7. Inspect Bilges and the Oily Water Separator

- Ensure bilges are free from excessive accumulation of oil or water.
- Check the condition and readiness of the oily water separator.

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8. Monitor Electrical Generation and Distribution

- Observe generator load sharing, voltage, frequency, and switchboard conditions.
- Ensure adequate reserve power is available.

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9. Investigate and Respond to Alarms

- Acknowledge alarms promptly.
- Determine the cause and take corrective action.
- Inform the Chief Engineer of any serious defect or abnormal condition.

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10. Ensure Safe Operation of Machinery Spaces

- Maintain cleanliness and good housekeeping.
- Check for leaks, overheating, unusual noises, and potential fire hazards.
- Ensure that safety equipment and emergency systems remain ready for use.

Other Acceptable Duties

Examiners may also accept:

- Checking potable water levels and sewage systems.
- Monitoring boiler water levels and treatment.
- Testing standby machinery.
- Ensuring the machinery space defect book is updated.
- Preparing machinery for changes in operating conditions.
- Supervising engine room ratings on watch.

Exam-Style Answer

Routine watchkeeping duties include monitoring the main engine and auxiliary machinery, checking lubricating oil, cooling water and fuel systems, making engine log entries, inspecting bilges and the oily water separator, monitoring generators and the switchboard, responding to alarms, maintaining machinery space cleanliness, and reporting defects or abnormal conditions to the Chief Engineer.

Quick Revision Memory Aid

"M-A-L-C-F-L-B-E-A-S"

- **M**ain engine checks
- **A**uxiliary machinery inspections
- **L**ubricating oil checks
- **C**ooling water monitoring
- **F**uel system checks
- **L**og book entries
- **B**ilges and OWS inspections
- **E**lectrical system monitoring
- **Al**arm response
- **S**afe housekeeping and defect reporting

These are the standard routine duties expected of a duty watchkeeping engineer under the STCW Code and the Code of Safe Working Practices.

2. With reference to Oily Water Separators (OWS) and the pumping of bilges, explain EACH of the following:

(a) why a positive displacement pump is preferable to a centrifugal pump as the main bilge pump; (2)

(b) why it is important that the flow rate to the separator is not exceeded; (2)

(c) why the discharge overboard line should be higher than the OWS; (2)

(d) how detergents used for bilge cleaning can affect the operation of the separator; (2)

(e) why an air release is fitted to the top of the shell of the OWS, (2)

2. With reference to Oily Water Separators (OWS) and the pumping of bilges, explain EACH of the following:

(a) Why a positive displacement pump is preferable to a centrifugal pump as the main bilge pump. (2 marks)

Explanation

A **positive displacement (PD) pump** is preferred because:

- It can maintain a nearly constant flow regardless of changes in discharge pressure.
- It has a good **self-priming capability**, allowing it to handle mixtures of water, oil, and air commonly found in bilges.

In contrast, a centrifugal pump may lose suction if air enters the system and its output varies with back pressure.

Exam-Style Answer

> A positive displacement pump is preferred because it is self-priming and delivers a constant flow even when handling air/oil mixtures and varying discharge pressures, making it more reliable for bilge duties.

(b) Why it is important that the flow rate to the separator is not exceeded. (2 marks)

Explanation

The OWS is designed to operate at a **specified maximum throughput**.

If the flow rate is exceeded:

- The retention time inside the separator is reduced.
- Oil droplets do not have sufficient time to coalesce and separate from the water.
- Oil carry-over may occur, causing the discharge to exceed the **15 ppm limit**.

Exam-Style Answer

> The separator's rated flow must not be exceeded because insufficient separation time will result in poor oil removal and possible discharge of oily water above the statutory 15 ppm limit.

(c) Why the discharge overboard line should be higher than the OWS. (2 marks)

Explanation

The overboard discharge pipe is arranged higher than the separator to:

- Prevent seawater flowing back into the OWS when the system is shut down.
- Prevent siphoning effects.
- Protect the separator and associated equipment from flooding and contamination.

Exam-Style Answer

> The overboard line is kept higher than the separator to prevent back-flooding or siphoning of seawater into the OWS when the unit is stopped.

(d) How detergents used for bilge cleaning can affect the operation of the separator. (2 marks)

Explanation

Detergents and emulsifying agents:

- Break oil into very fine droplets.
- Form stable **oil-water emulsions**.
- Prevent the oil droplets from coalescing and rising to the surface.

As a result:

- The OWS efficiency is reduced.
- The oil content monitor may indicate excessive oil levels.
- Discharge overboard may not be possible.

Exam-Style Answer

> Detergents emulsify the oil, producing very fine droplets that cannot separate easily. This reduces the effectiveness of the OWS and may prevent compliance with the 15 ppm discharge requirement.

(e) Why an air release is fitted to the top of the shell of the OWS. (2 marks)

Explanation

An air release or vent is fitted to:

- Remove trapped air and gases from the separator.

- Prevent air pockets forming inside the shell.
- Ensure the separator remains completely filled with liquid.
- Improve separation efficiency by maintaining steady flow conditions.

Exam-Style Answer

An air release is fitted to vent trapped air and gases from the separator, preventing air pockets and ensuring efficient oil-water separation.

Full Exam-Style Answers

(a)

A positive displacement pump is preferred because it is self-priming and can maintain a constant flow while handling air and oily bilge mixtures.

(b)

Exceeding the separator's rated flow reduces retention time, resulting in inadequate separation and possible discharge above the 15 ppm limit.

(c)

The overboard discharge line is arranged higher than the OWS to prevent seawater backflow and siphoning into the separator.

(d)

Detergents create oil-water emulsions that inhibit coalescence of oil droplets and reduce the separator's effectiveness.

(e)

The air release removes trapped air from the separator shell, preventing air locks and maintaining efficient operation.

Quick Revision Table

Part	Key Point
(a)	PD pump is self-priming and gives constant flow

(b) Excess flow reduces separation efficiency

(c) Prevents seawater backflow/siphoning

(d) Detergents emulsify oil and hinder separation

(e) Air release removes trapped air and prevents air locks

3. With reference to marine diesel oil:

(a) define EACH of the following terms, stating the unit used in EACH:

(i) density; (2)

(ii) viscosity; (2)

(iii) flash point. (2)

(b) excluding the THREE terms listed in part (a), state FOUR items of information contained on a Bunker delivery note. (4)

3. With reference to marine diesel oil:

(a) Define EACH of the following terms, stating the unit used in EACH:

(i) Density (2 marks)

Definition

> **Density** is the mass of fuel contained in a unit volume at a specified temperature.

It indicates how heavy the fuel is for a given volume.

Unit

- **kg/m³ (kilograms per cubic metre)**

Density is commonly quoted at **15°C**.

Example

Marine gas oil may have a density of **860 kg/m³ at 15°C**.

(ii) Viscosity (2 marks)

Definition

Viscosity is the measure of a fuel's resistance to flow or internal friction between adjacent layers of the liquid.

It indicates how easily the fuel can be pumped and atomised.

Unit

- **mm²/s (square millimetres per second)**

This is equivalent to:

- **Centistokes (cSt)**

and is normally specified at **40°C** for marine diesel oils.

Example

MGO may have a viscosity of **3–6 cSt at 40°C**.

(iii) Flash Point (2 marks)

Definition

Flash Point is the lowest temperature at which a fuel gives off sufficient vapour to form an ignitable mixture with air that flashes momentarily when an external ignition source is applied.

The fuel does **not continue to burn** once the ignition source is removed.

Unit

- **Degrees Celsius (°C)**

Example

Under SOLAS, marine fuel oils used in machinery spaces generally require a flash point of at least **60°C**.

Exam-Style Answer for Part (a)

Density: Mass per unit volume of fuel, measured in **kg/m³**.

Viscosity: Resistance of a fuel to flow, measured in **mm²/s (cSt)**.

Flash Point: Lowest temperature at which fuel vapours ignite momentarily, measured in **°C**.

(b) Excluding the THREE terms listed in part (a), state FOUR items of information contained on a Bunker Delivery Note. (4 marks)

A **Bunker Delivery Note (BDN)** provides details of the fuel supplied to the vessel.

Excluding density, viscosity, and flash point, four items that may be stated are:

1. Name and IMO Number of the Receiving Ship

- Identifies the vessel receiving the fuel.

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2. Port and Date of Bunkering

- Records where and when the fuel was supplied.

---

3. Name, Address, and Contact Details of the Fuel Supplier

- Identifies the bunker supplier.

---

4. Quantity of Fuel Delivered

- Usually expressed in:
  - **Metric tonnes**, and/or
  - **Cubic metres (m³)**.

Other Acceptable Answers

Examiners may also accept:

- Product name or grade of fuel.
- Sulphur content (% m/m).
- Declaration of compliance with MARPOL Annex VI.
- Barge or tanker name.
- Signature of the supplier's representative.
- Purchaser's order reference.

Exam-Style Answer

(a)

Density is the mass per unit volume of fuel and is measured in **kg/m³**. Viscosity is the resistance of the fuel to flow and is measured in **mm²/s (cSt)**. Flash point is the lowest temperature at which fuel vapours flash momentarily in the presence of an ignition source and is measured in **°C**.

(b)

Four items contained in a Bunker Delivery Note are:

- Name and IMO number of the receiving ship,
- Port and date of bunkering,
- Name and details of the fuel supplier,
- Quantity of fuel supplied.

Quick Revision Table

Term/Item	Definition	Unit
Density	Mass per unit volume	kg/m³
Viscosity	Resistance to flow	mm²/s (cSt)
Flash Point	Temperature at which vapours flash	°C
BDN Information	Ship details, supplier, date/port, quantity	–

Memory Aid for BDN:

"Ship – Supplier – Place – Quantity".

4. With reference to sewage treatment plants:

(a) state the purpose of the vent, and explain why it is fitted with a gauze; (3)

(b) explain the difference between aerobic and anaerobic micro organisms; (3)

(c) explain why air is bubbled through the effluent in the aeration tank; (2)

(d) explain why calcium hypochlorite is added to the treated sewage before discharge overboard. (2)

4. With reference to sewage treatment plants:

(a) State the purpose of the vent, and explain why it is fitted with a gauze. (3 marks)

Purpose of the Vent

The vent fitted to a sewage treatment plant is provided to:

- Allow the escape of gases produced during the sewage treatment process.
- Prevent pressure build-up or vacuum formation within the tank.
- Provide air circulation within the system, assisting the treatment process.

Why it is Fitted with a Gauze

The vent outlet is fitted with a **gauze (wire mesh)** to:

- Prevent insects, flies, and vermin from entering the tank.
- Stop debris from entering and obstructing the vent.
- Reduce the risk of blockage while still allowing free passage of gases.

Exam-Style Answer

> The vent allows gases to escape from the sewage treatment plant and prevents pressure or vacuum build-up within the tank. The vent is fitted with a gauze to prevent insects and debris entering the system while still permitting adequate ventilation.

(b) Explain the difference between aerobic and anaerobic micro-organisms. (3 marks)

Aerobic Micro-organisms

- Require a supply of **oxygen** to survive and function.
- Break down sewage in the presence of oxygen.
- Produce relatively harmless end products such as:
    - Carbon dioxide,
    - Water,
    - Nitrates.

Anaerobic Micro-organisms

- Function in the **absence of oxygen**.
- Decompose organic matter without air.
- Produce foul-smelling and potentially dangerous gases such as:
    - Hydrogen sulphide (H_2S),
    - Methane (CH_4),
    - Carbon dioxide (CO_2).

Exam-Style Answer

> Aerobic micro-organisms require oxygen to decompose sewage and produce mainly carbon dioxide and water. Anaerobic micro-organisms operate without oxygen and produce gases such as methane and hydrogen sulphide, which may be hazardous and offensive.

(c) Explain why air is bubbled through the effluent in the aeration tank. (2 marks)

Explanation

Air is bubbled through the sewage to:

- Supply oxygen required by the aerobic bacteria.
- Keep the sewage and activated sludge well mixed.
- Promote efficient biological breakdown of organic matter.

Exam-Style Answer

Air is bubbled through the effluent to provide oxygen for aerobic bacteria and to keep the contents of the tank mixed, thereby improving the efficiency of the treatment process.

(d) Explain why calcium hypochlorite is added to the treated sewage before discharge overboard. (2 marks)

Explanation

Calcium hypochlorite is added to:

- **Disinfect the treated sewage** by killing pathogenic bacteria and other harmful micro-organisms.
- Reduce the risk of disease transmission before the effluent is discharged into the sea.

Exam-Style Answer

Calcium hypochlorite is added to disinfect the treated effluent by destroying harmful bacteria and pathogens, ensuring that the discharged sewage meets health and environmental requirements.

Quick Revision Summary

Part	Key Point
(a)	Vent releases gases; gauze prevents insects and debris entering
(b)	Aerobic = requires oxygen; Anaerobic = no oxygen required
(c)	Air provides oxygen and mixing for aerobic bacteria
(d)	Calcium hypochlorite disinfects the effluent before discharge

Memory Aid

Vent – Bugs – Air – Bleach

- **Vent** gases,
- Keep **bugs** out,
- **Air** for aerobic bacteria,
- **Bleach** (calcium hypochlorite) for disinfection.

(a) State FOUR areas of an air conditioning system where the Legionella Bacteria may develop. (4)

(b) Detail the inspections and treatment to be carried out in THREE of the areas stated in part (a). (6)

With reference to air conditioning systems:

(a) State FOUR areas of an air conditioning system where the Legionella bacteria may develop. (4 marks)

Legionella bacteria thrive in warm, stagnant water and slime deposits within air-conditioning systems. Four areas where they may develop are:

1. Cooling Towers

- Warm recirculating water and accumulated sludge provide ideal conditions for bacterial growth.

2. Condensate Drain Pans (Drip Trays)

- Water collecting beneath cooling coils may stagnate if drainage is poor.

3. Humidifiers and Air Washers

- Water spray systems and reservoirs can harbour bacteria if not cleaned and treated.

4. Cooling Coils and Associated Drain Lines

- Biofilms, slime, and standing water around coils and drains can support Legionella growth.

Other acceptable answers include:

- Evaporative condensers,
- Water storage tanks,
- Dead legs in pipework,
- Spray chambers.

(b) Detail the inspections and treatment to be carried out in THREE of the areas stated in part (a). (6 marks)

1. Cooling Towers

Inspections

- Inspect regularly for:
  - Sludge accumulation,
  - Scale deposits,
  - Corrosion,
  - Algal growth,
  - Condition of drift eliminators.

Treatment

- Clean and disinfect the tower periodically.
- Maintain a suitable **biocide treatment programme**.
- Control water quality and blow down the system as required.

---

2. Condensate Drain Pans and Drain Lines

Inspections

- Check that drip trays are:
  - Clean,
  - Free draining,
  - Not retaining standing water.
- Inspect drain lines for blockages.

Treatment

- Remove sludge and debris.
- Clean and disinfect trays and drains.
- Repair any defects preventing proper drainage.

---

3. Humidifiers and Air Washers

Inspections

- Examine for:
    - Slime deposits,
    - Scale formation,
    - Dirty nozzles,
    - Stagnant water.

Treatment

- Drain and clean reservoirs regularly.
- Disinfect the system.
- Apply approved biocides.
- Ensure adequate water turnover and circulation.

Exam-Style Answer

(a)

Four areas where Legionella bacteria may develop are:

- Cooling towers,
- Condensate drip trays,
- Humidifiers or air washers,
- Cooling coils and associated drain lines.

(b)

Cooling towers should be inspected for sludge, scale, and biological growth, and treated by cleaning and biocide dosing. Condensate trays and drains should be checked for standing water and blockages, then cleaned and disinfected. Humidifiers and air washers should be inspected for slime and stagnant water, with reservoirs drained, cleaned, disinfected, and treated with approved biocides.

Quick Revision Summary

Area	Inspection	Treatment
Cooling Tower	Sludge, scale, algae	Clean, disinfect, biocide
Condensate Trays	Standing water, blocked drains	Clean and disinfect

Humidifiers/Air Washers	Slime, stagnant water	Drain, clean, biocide
Cooling Coils/Drains	Biofilm and deposits	Clean and maintain drainage

Memory Aid: "T-H-D-C"

- **T**owers
- **H**umidifiers
- **D**rip trays
- **C**oils and drains

6. With reference to reverse osmosis plants:

(a) explain the treatment that the feedwater undergoes to prevent blockage of the membranes; (3)

(b) describe how the purity of the water is measured and protected, stating the limits on purity set by the World Health Organisation; (5)

(c) outline the further treatment the permeated water undergoes before it can be used for domestic purpose. (2)

6. With reference to reverse osmosis plants:

(a) Explain the treatment that the feedwater undergoes to prevent blockage of the membranes. (3)

Before entering the reverse osmosis membranes, the seawater feed undergoes pre-treatment to prevent fouling and blockage of the membrane surfaces:

- **Coarse filtration** removes large debris, marine growth, sand, and suspended solids.
- **Fine filtration** (such as cartridge or micron filters, typically around 5 µm) removes smaller particles that could clog the membranes.
- **Chemical treatment (antiscalant dosing)** may be added to prevent the precipitation of mineral salts and scale formation on the membrane surfaces.

(b) Describe how the purity of the water is measured and protected, stating the limits on purity set by the World Health Organisation. (5)

Measurement of Purity

- The purity of the permeate is monitored using a **salinity meter** or **conductivity meter**.
- Since dissolved salts increase electrical conductivity, a low conductivity reading indicates high-quality fresh water.
- Some plants may also use a **Total Dissolved Solids (TDS) meter** to indicate water purity directly.

Protection of Purity

- A **three-way diverting valve** is fitted in the product line.
- If the salinity or conductivity rises above the acceptable limit, the valve automatically diverts the water back to the feed or reject line instead of allowing it into the potable water tanks.
- Audible and visual alarms may also be activated to alert the operator.

WHO Limits

According to World Health Organisation recommendations for potable water:

- **Total Dissolved Solids (TDS):** should generally not exceed **500 mg/L (500 ppm)**.
- This corresponds approximately to a conductivity of about **750–800 μS/cm**, although TDS is the more commonly quoted value.

(c) Outline the further treatment the permeated water undergoes before it can be used for domestic purpose. (2)

Before being supplied for domestic use, the permeate usually undergoes further treatment:

- **Sterilisation**, commonly by chlorination, ultraviolet treatment, or silver ion dosing, to destroy harmful microorganisms.
- **Mineral conditioning (remineralisation)** may be carried out to improve taste and reduce the corrosive nature of the very pure RO water before it enters the domestic fresh water system.

Exam-style answer

(a) Feedwater is passed through coarse and fine filters to remove suspended matter and is dosed with antiscalant chemicals to prevent scale formation and membrane blockage.

(b) Water purity is measured using conductivity, salinity, or TDS meters. A diverting valve prevents contaminated water from entering the potable water tanks by rejecting water of excessive salinity. WHO guidelines recommend a maximum TDS of approximately **500 ppm** for drinking water.

(c) The permeate is sterilised and may be remineralised before being supplied for domestic consumption.

7. With reference to the motion of a vessel in the water:

(a) list the SIX degrees of freedom, describing the meaning of EACH term; (6)

(b) sketch the position of a *bilge keel*, describing how it reduces vessel motion. (4)

7. With reference to the motion of a vessel in the water:

(a) List the SIX degrees of freedom, describing the meaning of EACH term. (6)

A vessel can move in six different ways, known as the **six degrees of freedom**. These consist of three translational movements and three rotational movements.

Degree of Freedom	Description
Surge	Forward and backward movement of the vessel along its longitudinal axis.
Sway	Side-to-side movement of the vessel along its transverse axis.
Heave	Vertical up-and-down movement of the vessel.
Roll	Rotation of the vessel about its longitudinal axis, causing the ship to tilt from side to side.
Pitch	Rotation about the transverse axis, causing the bow and stern to move alternately up and down.
Yaw	Rotation about the vertical axis, causing the bow to swing to port or starboard.

(b) Sketch the position of a bilge keel, describing how it reduces vessel motion. (4)

Position of a Bilge Keel

Bilge keels are fitted externally to the hull on both sides of the ship, along the **bilge region** where the ship's side meets the bottom. They usually extend for a considerable length amidships.

```
             Deck
          __________
         /          \
        /            \
       /              \
      /                \
     /                  \
    /                    \
   |                      |
   |                      |
   |      \       /       |
   |       \_____/        |
   |        |   |         |
   |        |   | ← Bilge keel
   |        |   |         |
    \____________________/
```

(Cross-sectional view of a ship)

How a Bilge Keel Reduces Vessel Motion

- Bilge keels primarily reduce **rolling motion**.
- When the vessel rolls, the bilge keels move through the surrounding water and create **hydrodynamic resistance (drag)**.
- This resistance absorbs energy from the rolling motion and opposes the movement.
- As a result, the **amplitude and rate of roll are reduced**, making the vessel more stable and improving passenger comfort and safety.

Exam-style answer

(a) The six degrees of freedom are:

1. Surge – fore and aft movement.
2. Sway – transverse side-to-side movement.
3. Heave – vertical movement.
4. Roll – rotation about the longitudinal axis.
5. Pitch – rotation about the transverse axis.
6. Yaw – rotation about the vertical axis.

(b) Bilge keels are long fin-like projections fitted externally along the bilges on each side of the ship, usually amidships. They reduce **rolling** by creating drag as they move through the water during rolling, thereby dissipating energy and decreasing the ship's rolling amplitude.

8. (a) Explain the need for fitting, location, and operation of an engine room fire main isolation valve. (4)

(b) State the type of valve used in part (a). (1)

(c) Describe, with the aid of a sketch, the construction of a sprinkler head. (5)

8.

(a) Explain the need for fitting, location, and operation of an engine room fire main isolating valve. (4)

Need for fitting

An **engine room fire main isolating valve** is fitted to ensure that, if the section of the fire main within the machinery space becomes damaged by fire or explosion, the remainder of the ship's fire main system can still supply water to fight the fire from outside the machinery space.

Without this valve, a ruptured fire main in the engine room could render the entire fire-fighting system ineffective.

Location

- It is fitted **outside the machinery space**, in an accessible and protected position.
- The valve is installed on the fire main at the point where the fire main enters the engine room.
- Its location allows it to be operated without personnel having to enter the fire-affected space.

Operation

- Under normal conditions, the valve remains **open**.
- If the engine room fire main is damaged, the valve is **closed remotely or manually from outside the machinery space**.
- This isolates the engine room section while maintaining pressure and water supply to hydrants elsewhere on the vessel.

(b) State the type of valve used in part (a). (1)

The isolating valve is usually a:

- **Screw-down non-return (SDNR) valve**.

(An SDNR valve allows the fire main to be isolated while preventing reverse flow.)

(c) Describe, with the aid of a sketch, the construction of a sprinkler head. (5)

Construction of a sprinkler head

A sprinkler head generally consists of:

- A **body/frame** connected to the sprinkler pipework.
- A **water orifice** through which water is discharged.
- A **deflector plate** that distributes the water into a fine spray pattern.
- A **heat-sensitive element**, either:
  - a **fusible metal link**, or
  - a **glass bulb containing a liquid** that expands and bursts at a predetermined temperature.
- A **cap or sealing plug** held in place by the heat-sensitive element to prevent water discharge under normal conditions.

Operation

- When the surrounding temperature reaches the sprinkler's rated value, the fusible link melts or the glass bulb shatters.
- The sealing cap is released.
- Water flows through the orifice and strikes the deflector plate.
- The deflector breaks the stream into a spray, distributing water over the protected area.

Sketch

```
   Deflector Plate
 __________________
       /\
      /  \
     /____\
        |
        |
  Glass Bulb /
 Fusible Link
        |
    Sealing Cap
   ___________
  |           |
  | Orifice   |
  |___________|
       |
       |
 Sprinkler Body
       |
  To Fire Main
```

Exam-style answer

(a) The fire main isolating valve enables the engine room section of the fire main to be isolated if damaged by fire, ensuring the remainder of the system remains operational. It is located outside the machinery space where it can be safely operated and is normally left open, being closed only to isolate the affected section.

(b) The valve used is an **SDNR (Screw-Down Non-Return) valve**.

(c) A sprinkler head consists of a body, orifice, sealing cap, heat-sensitive glass bulb or fusible link, and a deflector plate. When heated to its operating temperature, the heat-sensitive element fails, allowing water to strike the deflector and be discharged as a spray over the protected area.

9. Describe, with the aid of a sketch, the construction and operation of a *thermistor* type rate of rise heat detector. (10)

9. Describe, with the aid of a sketch, the construction and operation of a thermistor type rate-of-rise heat detector. (10)

Construction

A **thermistor type rate-of-rise heat detector** is designed to detect a **rapid increase in temperature**, rather than waiting for a fixed temperature to be reached.

The detector consists of:

- A **protective casing** with openings to allow surrounding air to enter.
- One or more **thermistors** (temperature-sensitive resistors), usually of the **Negative Temperature Coefficient (NTC)** type, whose resistance decreases as temperature increases.
- A **reference thermistor**, enclosed within the detector so that it responds more slowly to temperature changes.
- An **exposed thermistor**, directly exposed to the surrounding air and therefore responding quickly to temperature changes.
- An **electronic comparison circuit** or bridge circuit.
- An **amplifier and relay/output circuit** connected to the fire alarm control panel.

Sketch

```
          Protective Cover
     _________________________
    /                         \
   /   Air openings            \
  |   o   o   o   o   o         |
  |                             |
  |  Exposed Thermistor         |
  |       (rapid response)      |
  |             •               |
  |                             |
  |  Reference Thermistor       |
  |   (insulated/enclosed)      |
  |             •               |
  |                             |
  |_____________________________|
                |
                |
      Electronic Comparator
                |
        Amplifier/Relay
                |
      Fire Alarm Control Panel
```

Operation

1. Under **normal conditions**, both thermistors are at approximately the same temperature and therefore have similar resistance values. The detector remains in its normal condition.
2. If the ambient temperature rises **slowly**, both thermistors change resistance at nearly the same rate, and no alarm is activated.
3. In the event of a **fire**, the surrounding air temperature rises rapidly.
4. The **exposed thermistor** responds immediately, its resistance decreasing quickly.
5. The **reference thermistor**, being insulated from the rapid temperature change, responds more slowly.
6. The resulting difference in resistance creates an **imbalance in the electronic bridge circuit**.
7. This imbalance is detected and amplified by the electronic circuitry.
8. The relay operates, sending a signal to the **fire alarm control panel**.
9. Audible and visual alarms are activated to warn personnel of the fire condition.
10. Once the detector is reset and temperatures return to normal, the detector can resume normal monitoring.

Advantages

- Provides **early warning** of rapidly developing fires.
- Less likely to give false alarms due to normal gradual temperature variations.
- Reliable operation with no moving mechanical parts.
- Suitable for machinery spaces where smoke detectors may be affected by dust, fumes, or humidity.

Exam-style answer

A thermistor type rate-of-rise heat detector consists of an exposed thermistor, an insulated reference thermistor, an electronic comparator circuit, amplifier, and alarm relay housed within a ventilated casing. During normal conditions both thermistors have similar resistance values. A rapid rise in temperature causes the exposed thermistor to change resistance much faster than the reference thermistor, creating an imbalance in the circuit. This operates the alarm relay and activates the fire alarm system, giving early warning of a rapidly developing fire.

10. (a) State the meaning of EACH of the following terms in relation to a vessel's size:

(i) gross tonnage; (2)

(ii) net tonnage; (1)

(iii) lightweight; (2)

(iv) deadweight; (2)

(v) displacement. (2)

(b) State the relationship between Lightweight, Deadweight and Displacement. (1)

10.

(a) State the meaning of EACH of the following terms in relation to a vessel's size:

(i) Gross Tonnage (GT) (2)

- **Gross tonnage** is a measure of the **total enclosed internal volume of a ship**.
- It includes all enclosed spaces used for cargo, machinery, accommodation, stores, and navigation.
- It is a **dimensionless number** used for regulations, port dues, manning requirements, and certification purposes.

(ii) Net Tonnage (NT) (1)

- **Net tonnage** is a measure of the **useful earning capacity of the ship**.
- It represents the volume of cargo and passenger spaces available for commercial use, excluding spaces such as machinery rooms, crew accommodation, and navigation areas.

(iii) Lightweight (Light Displacement) (2)

- **Lightweight** is the actual weight of the vessel itself when complete and ready for service, but **without cargo, fuel, lubricating oil, ballast water, fresh water, stores, passengers, crew, or provisions**.
- It includes:
  - Hull structure,
  - Machinery,
  - Equipment and fittings.

(iv) Deadweight (DWT) (2)

- **Deadweight** is the total weight the ship can safely carry.
- It includes the weight of:
  - Cargo,
  - Fuel oil,
  - Lubricating oil,
  - Fresh water,
  - Ballast water,
  - Stores and provisions,
  - Passengers and crew.

(v) Displacement (2)

- **Displacement** is the total weight of the ship and everything on board at a particular draft.
- It is equal to the **weight of the volume of water displaced by the vessel** (Archimedes' Principle).

(b) State the relationship between Lightweight, Deadweight and Displacement. (1)

The relationship is:

Displacement=Lightweight+Deadweight\text{Displacement} = \text{Lightweight} + \text{Deadweight}Displacement=Lightweight+Deadweight

Therefore:

Displacement = Lightweight + Deadweight

or equivalently,

Deadweight = Displacement − Lightweight

Exam-style Answer

(a)

1. **Gross tonnage:** Total enclosed volume of the vessel used for regulatory purposes.
2. **Net tonnage:** Volume of spaces available for carrying cargo and passengers.
3. **Lightweight:** Weight of the complete vessel excluding cargo, fuel, stores, ballast, passengers, crew, and consumables.
4. **Deadweight:** Total weight of cargo and all consumable loads that the vessel can carry.
5. **Displacement:** Total weight of the vessel and everything on board, equal to the weight of water displaced.

(b)

Displacement = Lightweight + Deadweight.