CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY - MARINE ENGINEER OFFICER

STCW 78 as amended CHIEF ENGINEER REG. III/2 - "YACHT 2"
STCW 78 as amended SMALL VESSEL CHIEF ENGINEER <3000 GT, <9000 kW UNLIMITED

058-12 - GENERAL ENGINEERING SCIENCE II

FRIDAY, 11 DECEMBER 2020

1400 - 1600 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

Notes for the guidance of candidates:

1. Examinations administered by SQA on behalf of the Maritime & Coastguard Agency.
2. Candidates are required to obtain 50% of the total marks allocated to this paper to gain a pass **AND** also obtain a minimum 40% in Sections A and B of the paper.
3. Non-programmable calculators may be used.
4. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Maritime & Coastguard Agency

SQA

GENERAL ENGINEERING SCIENCE II

Attempt ALL questions

Marks for each question are shown in brackets.

All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Section A

1. Describe the THREE modes of heat transfer and give an example of each. (9)

2. (a) State Charles' Law for a perfect gas. (2)

   (b) A perfect gas has volume of 30 litres at a pressure and temperature of 0.95 bar and 24°C respectively. The temperature of the gas rises to 162°C at constant pressure.

   Calculate EACH of the following:

   (i) the increase in the volume of the gas in m^3; (3)

   (ii) the mass of gas. (3)

   Note: for the gas R = 0.29 kJ/kgK

3. With reference to the performance of a diesel engine.

   Define EACH of the following terms and state the formula for calculating the values:

   (a) indicated power; (2)

   (b) brake power; (2)

   (c) power loss to lubricating oil; (2)

   (d) power loss to exhaust. (2)

4. (a) State TWO thermodynamic and TWO general properties required of a good refrigerant. (4)

   (b) For the FOUR key points in a simple refrigeration circuit state the condition of the refrigerant. (4)

[OVER

5. Butane (C_4H_{10}) is completely burned in 30% excess air by mass.

Calculate EACH of the following:

(a) the mass of carbon dioxide in the exhaust gases per kg of fuel; (4)

(b) the mass of nitrogen in the exhaust gases per kg of fuel. (4)

6. (a) Explain what is meant by EACH of the following terms:

(i) specific heat capacity; (3)

(ii) specific enthalpy of evaporation. (3)

(b) 6 kg of liquid at 20°C has 1240 kJ of heat transferred to it raising its temperature to 92°C.

Determine the specific heat capacity of the liquid. (3)

Section B

7. (a) Determine the thrust load in MN on a cofferdam (bulkhead) 25 m wide by 26 m deep when flooded with seawater of density 1025 kg/m^3 on one side only. (4)

   (b) Determine the gauge pressure, in bar, at the lowest point on the bulkhead. (4)

8. A ship has a displacement of 35500 tonne.

   Determine the distance a mass of Δ/500 tonne, already on board, must be moved off the Centreline to cause the ship to list by exactly 1°. (8)

   Note: $m \times d = \Delta GM \tan \theta$
   $KM = 6.2\ m$
   $KG = 5.3\ m.$

9. (a) Explain the main differences in molecular structure which determines whether the material is a conductor or an insulator. (4)

   (b) State examples of an electric current being used for EACH of the following:

   (i) its magnetic effect; (2)

   (ii) its chemical effect; (2)

   (iii) its heating effect. (2)

10. (a) In a moving coil instrument state the purpose of a shunt resistor. (4)

    (b) Describe with the aid of a diagram, the operation of a moving coil instrument. (4)

11. An electric fire operated from a 230 V supply has a heating element comprising two 25 Ω coils. The coils may be connected in series to give a low setting, or in parallel to give a high setting.

    Calculate EACH of the following:

    (a) the power output for the low setting; (4)

    (b) the power output for the high setting. (4)

[OVER

12. A conductor of 7.5 mm diameter has an effective length of 400 mm and carries a current of 20 A. The force on the conductor is 20 N.

Calculate EACH of the following:

(a) the flux density; (4)

(b) the magnetic flux. (4)

2. (a) State Charles' Law for a perfect gas. (2)

(b) A perfect gas has volume of 30 litres at a pressure and temperature of 0.95 bar and 24°C respectively. The temperature of the gas rises to 162°C at constant pressure.

Calculate EACH of the following:

(i) the increase in the volume of the gas in m^3; (3)

(ii) the mass of gas. (3)

Note: for the gas R = 0.29 kJ/kgK

a) $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$V_1 = 30 = 0.03$ $V_2 = x$
$P_1 = 0.95\ bar$ $P_2 = 0.95$
$T_1 = 24°C$ $T_2 = 162$
$+273 = 297$ $+273 = 435$

$\frac{0.03}{297} = \frac{x}{435}$

$x = 0.043939\ m^3$

Δvol = New − old

$0.043939 - 0.03 = 0.13939 m^3$

$Pv = mRt$ $t = 24 + 273$

$P = 95{,}000$

$\frac{95000 \times 0.03}{290 \times (297)} = 0.0330895$ Kg

3. With reference to the performance of a diesel engine.

Define EACH of the following terms and state the formula for calculating the values:

(a) indicated power; (2)

(b) brake power; (2)

(c) power loss to lubricating oil; (2)

(d) power loss to exhaust. (2)

3a) IP is the heorectical power based upon number of cylinders, the pressure (Idicated mean pressure) , the length of the stroke, the corss sectional area on the cylinder, and the number of effective strokes per second, given by the formula IP=xplan. IP is given in watts.

b)BP the actual power as given by the drive shaft from the engine. Using the formual BP =T2*pi*n where n is the number of revolutions per sec and T is the torque as measured at the drive shaft given in Nm. BP is given in watts.

c)Power losses due to lubricating oil can be calculated by multiplying the mass flow rate of oil, by the heat capacity of the oil and the temperature differnential. (measure in watts)

$$\dot{Q} = \dot{m} c \Delta t$$

$\dot{Q}$ → Power $= \frac{J}{S}$; $\dot{m}$ = flow rate kg/sec

d)Power losses due to exahust gasses can calculated by multiplying the mass flow rate of the exhaust gasses and the heat capacity of the exhaust gasses and the temperature diff

$$\dot{Q} = \dot{m} c \Delta t$$

$\dot{Q}$ → Power $= \frac{J}{S}$; $\dot{m}$ = flow rate kg/sec

4. (a) State TWO thermodynamic and TWO general properties required of a good refrigerant. (4)

(b) For the FOUR key points in a simple refrigeration circuit state the condition of the refrigerant. (4)

[OVER

5. Butane (C_4H_{10}) is completely burned in 30% excess air by mass.

Calculate EACH of the following:

(a) the mass of carbon dioxide in the exhaust gases per kg of fuel; (4)

(b) the mass of nitrogen in the exhaust gases per kg of fuel. (4)

C = 12 O = 16 H = 1

Air 23% by mass oxygen

$C_4 = 12 \times 4 = 48$ $H_{10} = 1 \times 10 = 10$ $C_4H_{10} = 58$

Carbon

$\frac{48}{58} \times 1 = 0.827586$ kg

Hydrogen

0.17241379 kg

Burn the Carbon

$C + O_2 = CO_2$

$\frac{\text{Mass}}{\text{RAM}}$ $\frac{0.827586}{12} = \frac{x}{32}$

Mass of oxygen = 2.2068955

Mass of CO_2

0.827586 + 2.2068655 = 3.03445 kg

Burn the Hydrogen

$H_2 + O = H_2O$

$\frac{0.17241}{2} = \frac{x}{16}$

1.3793 kg of oxygen

b) Nitrogen

Mass of oxygen = 2.20689655 + 1.3793 = 3.58619655 kg

Mass of air (stoich) = $\frac{3.586196}{0.23}$ = 15.59215 kg

Mass of air (+30%) = 20.2698 kg

Nitrogen (77%) = 15.6 kg

6. (a) Explain what is meant by EACH of the following terms:

(i) specific heat capacity; (3)

(ii) specific enthalpy of evaporation. (3)

(b) 6 kg of liquid at 20°C has 1240 kJ of heat transferred to it raising its temperature to 92°C.

Determine the specific heat capacity of the liquid. (3)

a) i) the amount of energry required to heat 1kg of a material 1 degree kelvin

ii) the amount of energy required to turn 1kg of a liquid into a gas in (joules).

b) $Q = mc\Delta t$

m = 6 Kg

Q = 1,240,000

c = x

t = 92 - 20 = 72

$\frac{1,240,000}{6 \times 72}$ = 2870.370

2.87 kJ/kgK

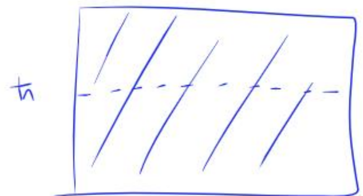
Section B

7. (a) Determine the thrust load in MN on a cofferdam (bulkhead) 25 m wide by 26 m deep when flooded with seawater of density 1025 kg/m^3 on one side only. (4)

(b) Determine the gauge pressure, in bar, at the lowest point on the bulkhead. (4)

$F = \rho g a \bar{h}$

$p = \rho g h$



a) Force $= 1025 \times 9.81 \times 25 \times 26 \times 13 = 84{,}966{,}862.5$ N

84.96686 MN

b) $P = 1025 \times 9.81 \times 26 = 261436.5$

2.614 bar

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8. A ship has a displacement of 35500 tonne.

Determine the distance a mass of $\Delta/500$ tonne, already on board, must be moved off the Centreline to cause the ship to list by exactly 1°. (8)

Note: $\dot{m} \times d = \Delta\, GM \tan\theta$
$KM = 6.2$ m
$KG = 5.3$ m.

$GM = 6.2 - 5.3 = 0.9$

$m = \frac{35500}{500} = 71$ tonnes

$\Delta = 35500$

$\theta = 1$

$\sout{71}\ x = \frac{35500 \times 0.9 \times \tan 1}{71}$

$x = 7.854779$ m

9. (a) Explain the main differences in molecular structure which determines whether the material is a conductor or an insulator. (4)

(b) State examples of an electric current being used for EACH of the following:

(i) its magnetic effect; (2)

(ii) its chemical effect; (2)

(iii) its heating effect. (2)

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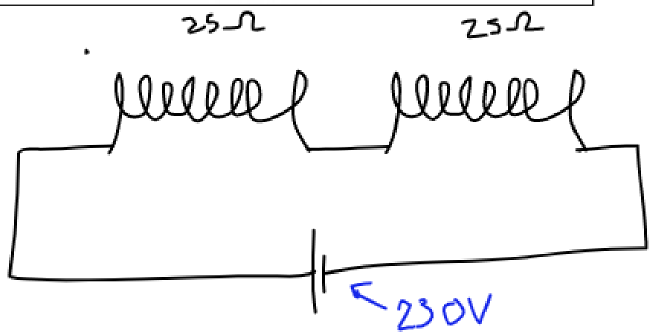
11. An electric fire operated from a 230 V supply has a heating element comprising two 25 Ω coils. The coils may be connected in series to give a low setting, or in parallel to give a high setting.

Calculate EACH of the following:

(a) the power output for the low setting; ✓ (4)

(b) the power output for the high setting. ✓ (4)

low)



$I = \frac{230}{50} = 4.6$

$I = 4.6$

$P = IV = 4.6 \times 230 = 1058$ W

high)

$\frac{1}{25} + \frac{1}{25} = \frac{2}{25}$ $R = 12.5$

$I = \frac{230}{12.5} = 18.4$ A

$P = IV = 18.4 \times 230 = 4232$ Watts

12. A conductor of 7.5 mm diameter has an effective length of 400 mm and carries a current of 20 A. The force on the conductor is 20 N.

Calculate EACH of the following:

(a) the flux density; (4)

(b) the magnetic flux. (4)

X Flux Density is 0.4 T =

magnetic Flux is 1.76715 Wb

a) $F = BIL \sin\theta$

$\frac{F}{IL} = B$

$20 = B \times 20 \times 0.4$

$\frac{20}{(20 \times 0.4)} = 2.5$

$B = \frac{\phi}{A}$

$2.5 = \frac{\phi}{\pi (3.75 \times 10^{-3})^2}$

1.104466×10^{-4} Wb