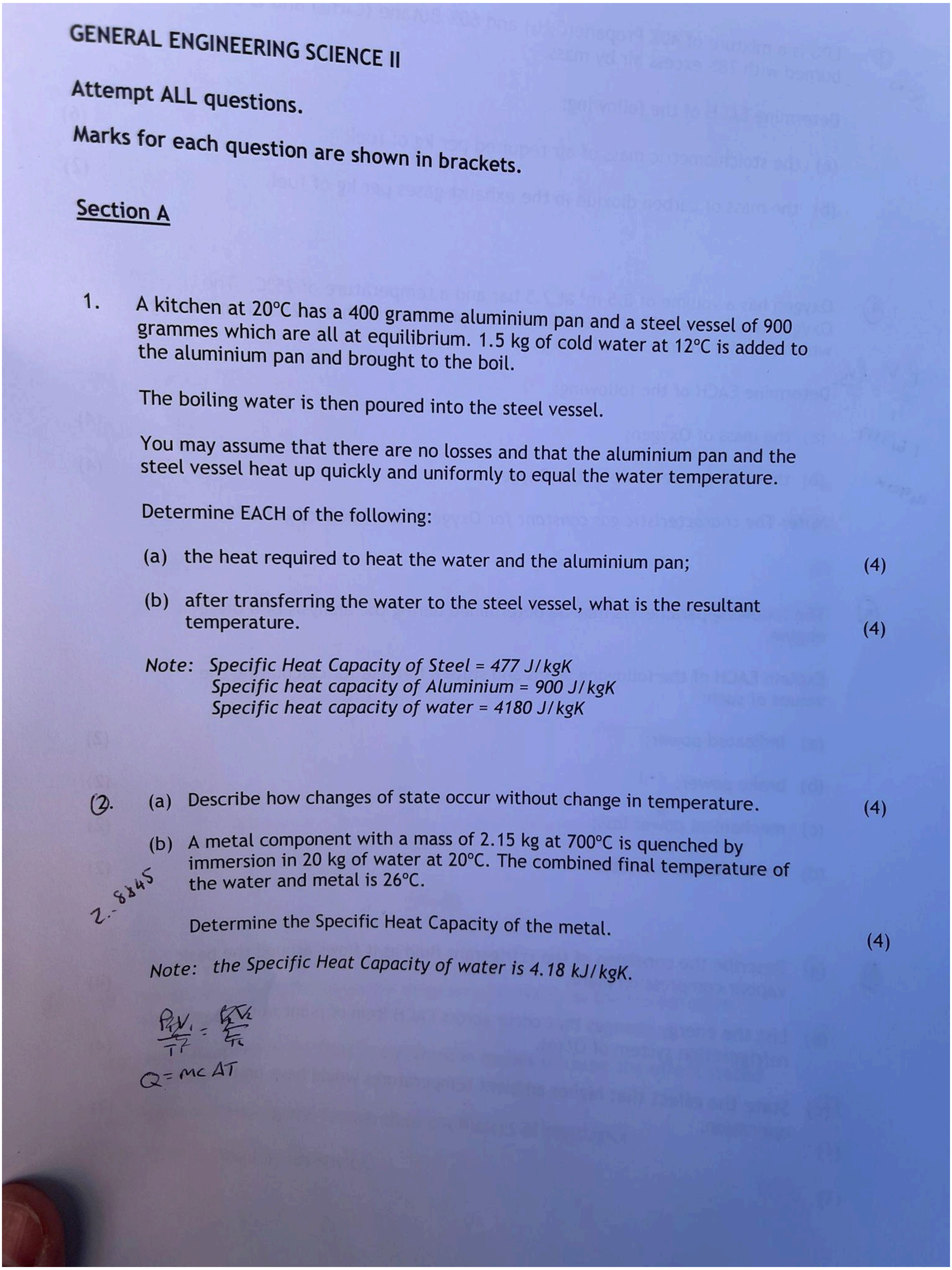


GENERAL ENGINEERING SCIENCE II

Attempt ALL questions.

Marks for each question are shown in brackets.

Section A

1. A kitchen at 20°C has a 400 gramme aluminium pan and a steel vessel of 900 grammes which are all at equilibrium. 1.5 kg of cold water at 12°C is added to the aluminium pan and brought to the boil.

The boiling water is then poured into the steel vessel.

You may assume that there are no losses and that the aluminium pan and the steel vessel heat up quickly and uniformly to equal the water temperature.

Determine EACH of the following:

(a) the heat required to heat the water and the aluminium pan; (4)

(b) after transferring the water to the steel vessel, what is the resultant temperature. (4)

Note: *Specific Heat Capacity of Steel = 477 J/kgK*
Specific heat capacity of Aluminium = 900 J/kgK
Specific heat capacity of water = 4180 J/kgK

②. (a) Describe how changes of state occur without change in temperature. (4)

(b) A metal component with a mass of 2.15 kg at 700°C is quenched by immersion in 20 kg of water at 20°C. The combined final temperature of the water and metal is 26°C.

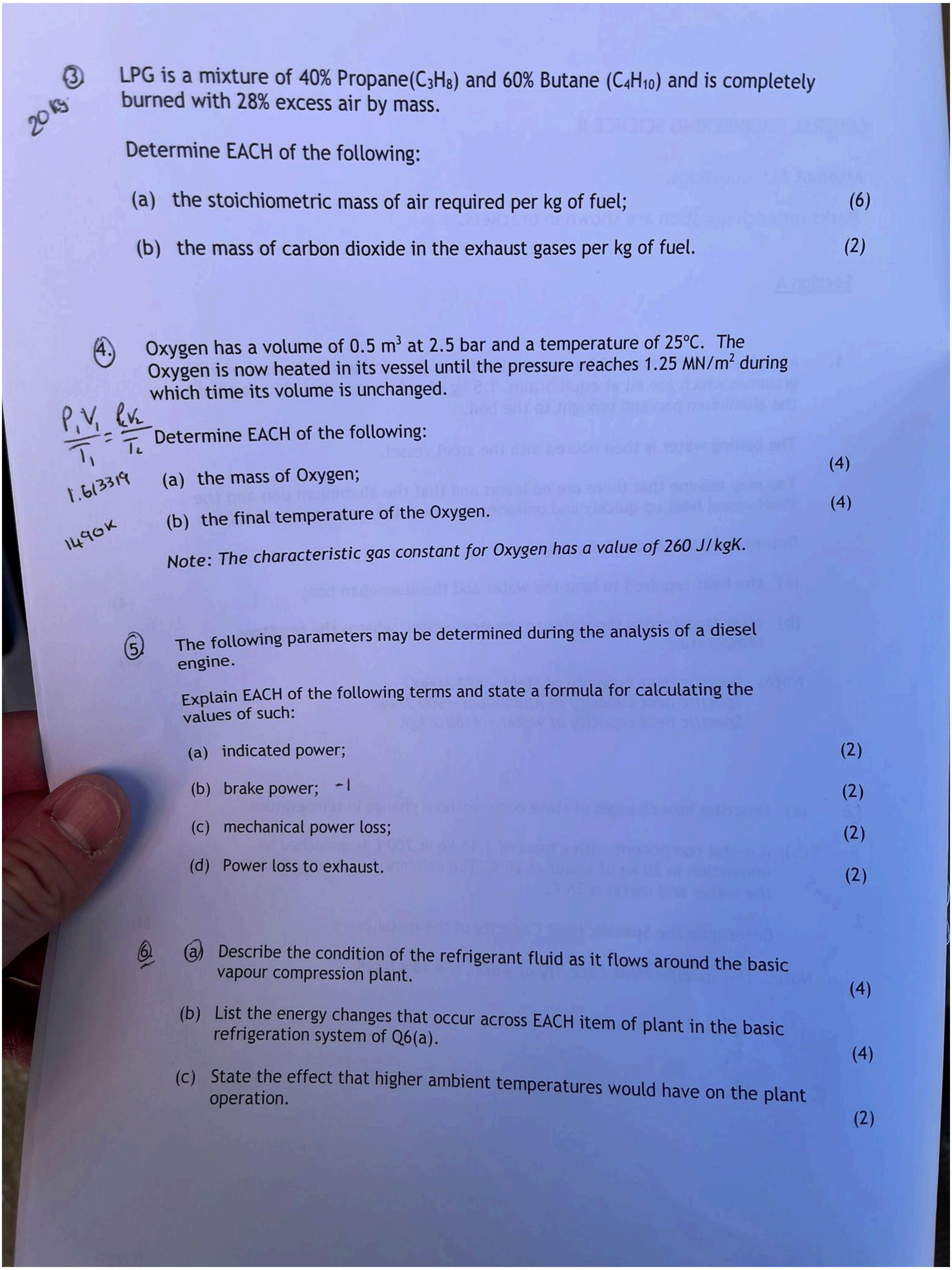
2.8845

Determine the Specific Heat Capacity of the metal. (4)

Note: *the Specific Heat Capacity of water is 4.18 kJ/kgK.*

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$Q = mc\Delta T$



2013

③ LPG is a mixture of 40% Propane(C_3H_8) and 60% Butane (C_4H_{10}) and is completely burned with 28% excess air by mass.

Determine EACH of the following:

(a) the stoichiometric mass of air required per kg of fuel; (6)

(b) the mass of carbon dioxide in the exhaust gases per kg of fuel. (2)

④ Oxygen has a volume of 0.5 m^3 at 2.5 bar and a temperature of 25°C. The Oxygen is now heated in its vessel until the pressure reaches 1.25 MN/m^2 during which time its volume is unchanged.

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Determine EACH of the following:

1.613319

(a) the mass of Oxygen; (4)

1490K

(b) the final temperature of the Oxygen. (4)

Note: The characteristic gas constant for Oxygen has a value of 260 J/kgK.

⑤ The following parameters may be determined during the analysis of a diesel engine.

Explain EACH of the following terms and state a formula for calculating the values of such:

(a) indicated power; (2)

(b) brake power; -1 (2)

(c) mechanical power loss; (2)

(d) Power loss to exhaust. (2)

⑥ ⓐ Describe the condition of the refrigerant fluid as it flows around the basic vapour compression plant. (4)

(b) List the energy changes that occur across EACH item of plant in the basic refrigeration system of Q6(a). (4)

(c) State the effect that higher ambient temperatures would have on the plant operation. (2)

Section B

7. (a) Copper is the most commonly used conductor of electricity. In relation to its structure, why is it a good conductor of electricity. lattice Structure (2)

(b) Cables with copper conductors often have PVC insulation. In relation to its structure, why is it not a good conductor of electricity. (2)

(c) Why do conductors have power losses. (2)

(d) How can power losses be determined in conductors. (2)

8. The power requirement for the circuit in figure Q8 is 1.5 kW.

Calculate EACH of the following:

(a) the supply current, I_s.; (2)

(b) the current (I_1) flowing in the resistor R_1; (2)

(c) the value of R_2; (2)

(d) the energy consumed in the 20 Ω resistor in 20 minutes. (2)

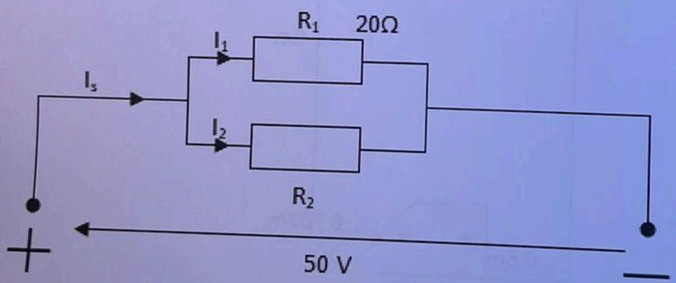


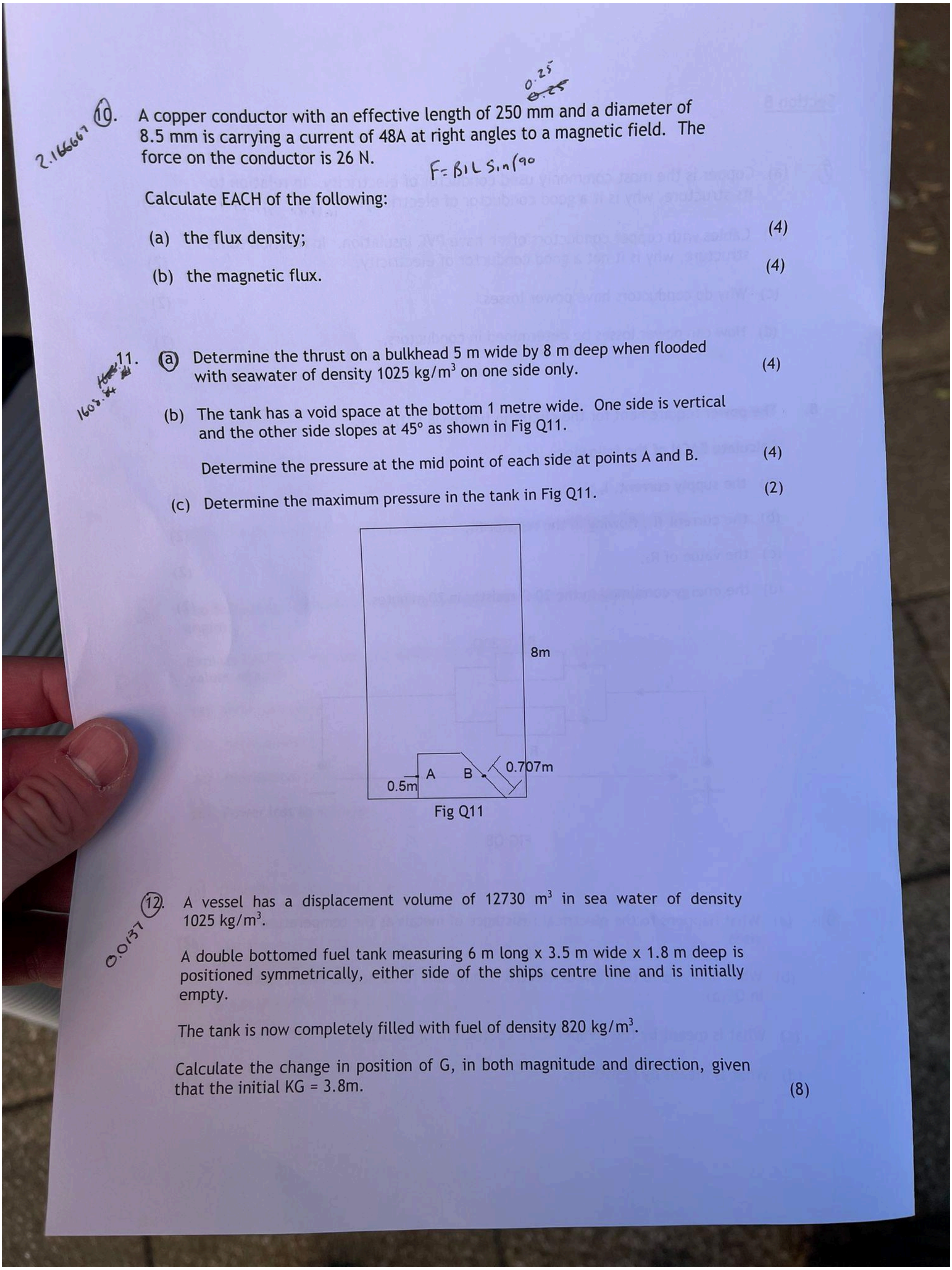
FIG Q8

9. (a) What happens to the electrical resistance of metals as the temperature rises; (2)

(b) What happens to the flow of electrons in metals to cause the effect stated in Q9(a); (2)

(c) What is meant by the temperature coefficient of resistance; (2)

(d) What is meant by resistivity. (2)



0.25 ~~0.25~~

2.166667 ⑩. A copper conductor with an effective length of 250 mm and a diameter of 8.5 mm is carrying a current of 48A at right angles to a magnetic field. The force on the conductor is 26 N.

F= BIL Sin(90

Calculate EACH of the following:

(a) the flux density; (4)

(b) the magnetic flux. (4)

1608.84 11. ⓐ Determine the thrust on a bulkhead 5 m wide by 8 m deep when flooded with seawater of density 1025 kg/m^3 on one side only. (4)

(b) The tank has a void space at the bottom 1 metre wide. One side is vertical and the other side slopes at 45° as shown in Fig Q11.

Determine the pressure at the mid point of each side at points A and B. (4)

(c) Determine the maximum pressure in the tank in Fig Q11. (2)

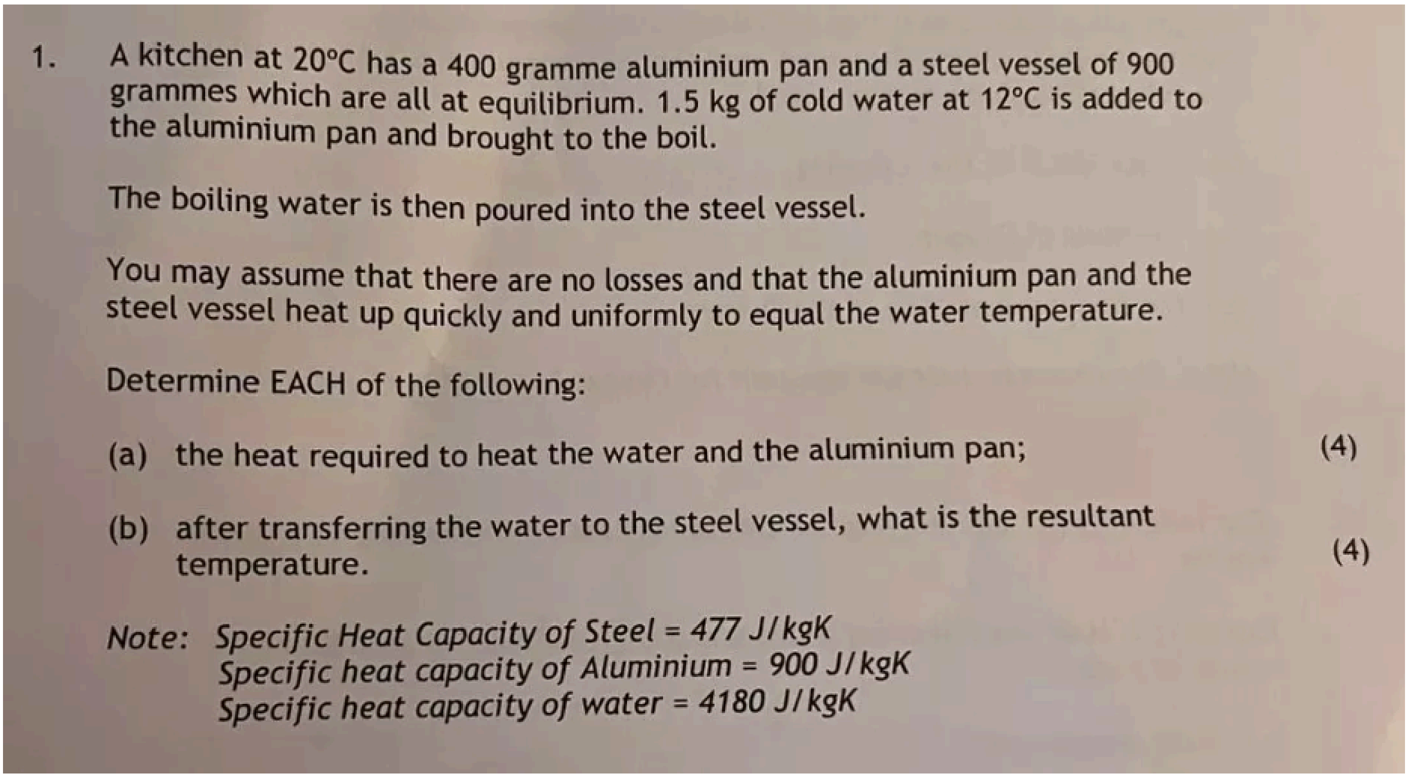
Fig Q11

0.0137 ⑫. A vessel has a displacement volume of 12730 m^3 in sea water of density 1025 kg/m^3.

A double bottomed fuel tank measuring 6 m long x 3.5 m wide x 1.8 m deep is positioned symmetrically, either side of the ships centre line and is initially empty.

The tank is now completely filled with fuel of density 820 kg/m^3.

Calculate the change in position of G, in both magnitude and direction, given that the initial KG = 3.8m. (8)



1. A kitchen at 20°C has a 400 gramme aluminium pan and a steel vessel of 900 grammes which are all at equilibrium. 1.5 kg of cold water at 12°C is added to the aluminium pan and brought to the boil.

The boiling water is then poured into the steel vessel.

You may assume that there are no losses and that the aluminium pan and the steel vessel heat up quickly and uniformly to equal the water temperature.

Determine EACH of the following:

(a) the heat required to heat the water and the aluminium pan; (4)

(b) after transferring the water to the steel vessel, what is the resultant temperature. (4)

Note: Specific Heat Capacity of Steel = 477 J/kgK
Specific heat capacity of Aluminium = 900 J/kgK
Specific heat capacity of water = 4180 J/kgK

a) <u>Alu</u> $Q = mc\Delta t$

Q

$m = 0.4 \text{ kg}$

$c = 900 \text{ J/kg k}$

$\Delta t = 80\,°\text{c}$

$Q_A = 0.4 \times 900 \times 80$

$Q_A = 28,800 \text{ J}$

<u>Water</u> $Q = mc\Delta t$

Q

$m = 1.5 \text{ kg}$

$c = 4180 \text{ J/kg k}$

$\Delta t = 88\,°\text{C}$

$Q_w = 1.5 \times 4180 \times 88$

$Q_w = 551760 \text{ J}$

$$\boxed{\text{total} = 580,560 \text{ J}}$$

b) $Q_{water} = Q_{steel}$

$$m c \Delta t = m c \Delta t$$

$$1.5(4180)(100 - x) = 0.9(477)(x - 12)$$

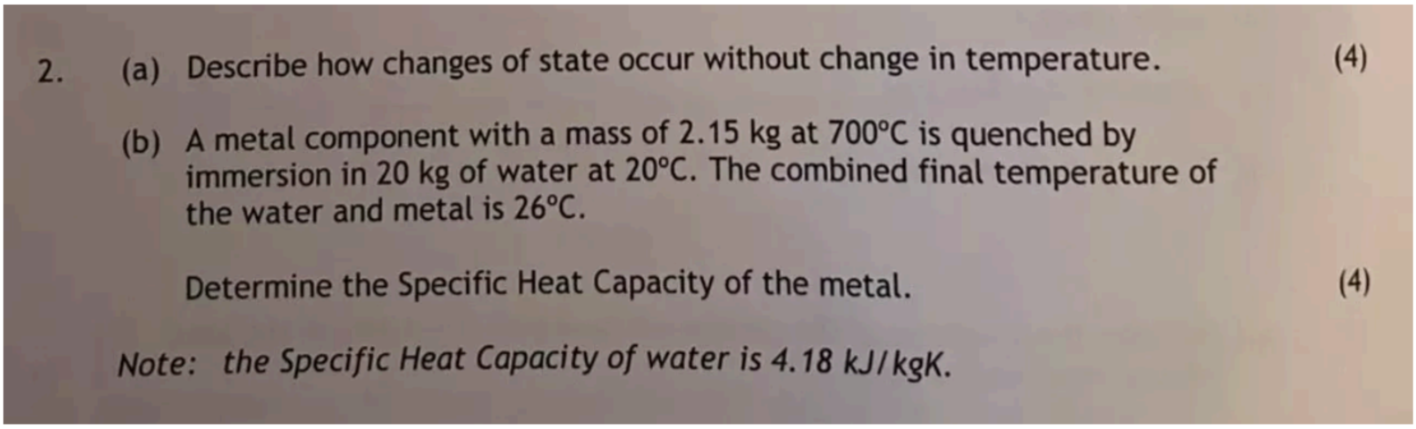
$$627{,}000 - 6270x = 429.3x - 5151.6$$

$$632151.6 = 6699.3x$$

$$\frac{632151.6}{6699.3} = x$$

$$\boxed{94.3608\,^\circ C} = x$$

Final temp



2. (a) Describe how changes of state occur without change in temperature. (4)

(b) A metal component with a mass of 2.15 kg at 700°C is quenched by immersion in 20 kg of water at 20°C. The combined final temperature of the water and metal is 26°C.

Determine the Specific Heat Capacity of the metal. (4)

Note: the Specific Heat Capacity of water is 4.18 kJ/kgK.

b)

metal

Q

$m = 2.15 \text{ Kg}$

$C = x$

$\Delta t = 700 - 26 = 674$

Water

Q

$m = 20 \text{ kg}$

$c = 4180 \text{ J/kgk}$

$\Delta t = 6$

$Q = mc\Delta t$

$Q_{loss} = Q_{gain}$

$Q_{metal} = Q_{water}$

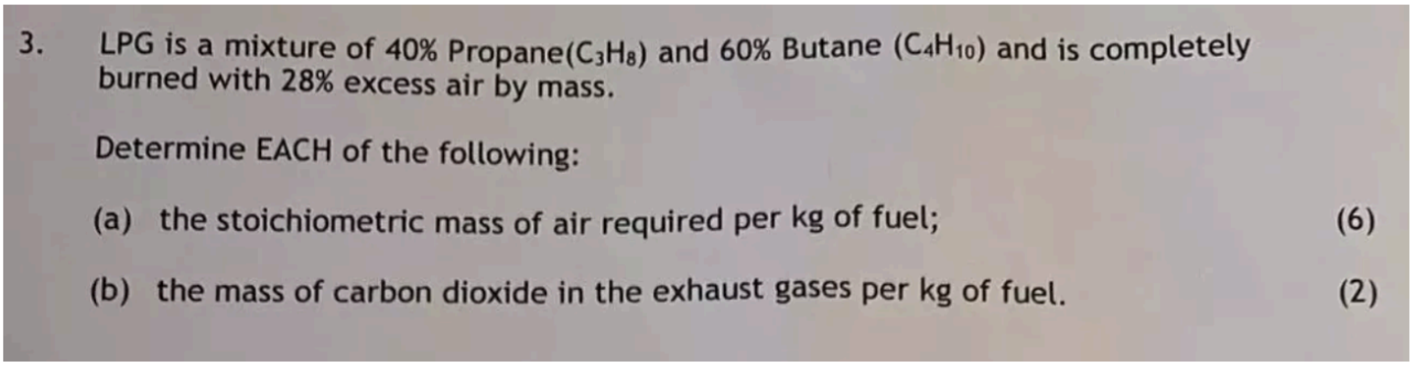
$mc\Delta t = mc\Delta t$

$2.15 \times x \times 674 = 20 \times 4180 \times 6$

$1449.1 x = 501600$

$x = \frac{501600}{1449.1}$

$x = \boxed{346.146 \text{ J/kgk}}$



3. LPG is a mixture of 40% Propane(C_3H_8) and 60% Butane (C_4H_{10}) and is completely burned with 28% excess air by mass.

Determine EACH of the following:

(a) the stoichiometric mass of air required per kg of fuel; (6)

(b) the mass of carbon dioxide in the exhaust gases per kg of fuel. (2)

H = 1 C = 12 O = 16 A:/ 23%

Propane @ 40% = 1kg × 0.4 = 0.4 kg

Carbon

3 × 12 = 36

$\frac{36}{44} \times 0.4 = \boxed{0.3272727 \text{ kg}}$

Hydrogen

8 × 1 = 8

$\frac{8}{44} \times 0.4 = \boxed{0.07272727 \text{ kg}}$

total

36 + 8 = 44

Butane @ 60% = 1 kg × 0.6 = 0.6 kg

Carbon

4 × 12 = 48

$\frac{48}{58} \times 0.6 = \boxed{0.49655 \text{ kg}}$

Hydrogen

10 × 1 = 10

$\frac{10}{58} \times 0.6 = \boxed{0.10344828 \text{ kg}}$

total

48 + 10 = 58

total Carbon

0.3272727 kg + 0.49655 kg

$= \boxed{0.823822 \text{ kg}}$

total Hydrogen

0.07272727 kg + 0.10344828 kg

$= \boxed{0.17617555 \text{ kg}}$

Burn Carbon

$$C + O_2 = CO_2$$

$$\text{mols} = \frac{\text{mass}}{\text{RAM}} \qquad \frac{0.823822}{12} = \frac{x}{32}$$

2.19685 kg of oxy is Req to burn Carbon

Burn Hydrogen

$$H_2 + O = H_2O$$

$$\frac{0.17617555}{2} = \frac{x}{16}$$

1.4094 kg of oxygen is Req to burn Hydrogen

a) stoich oxy 2.19685 kg + 1.4094 kg

$$= 3.60625 \text{ kg}$$

stoich Air @23%

$$x \, 0.23 = 3.60625$$

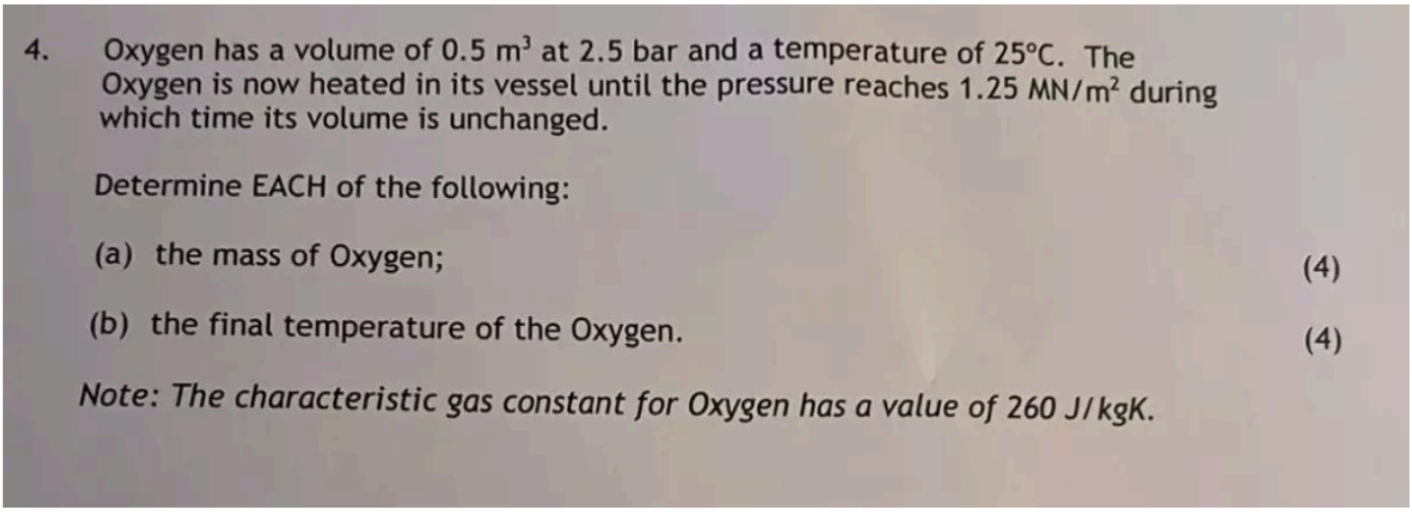
$$x = \frac{3.60625}{0.23}$$

$$x = \boxed{15.6793 \text{ kg}}$$

b) Mass of CO_2 = Mass of Carbon + Mass of oxygen

$$0.823822 + 2.19685$$

$$\boxed{3.020672 \text{ kg}}$$



4. Oxygen has a volume of 0.5 m³ at 2.5 bar and a temperature of 25°C. The Oxygen is now heated in its vessel until the pressure reaches 1.25 MN/m² during which time its volume is unchanged.

Determine EACH of the following:

(a) the mass of Oxygen; (4)

(b) the final temperature of the Oxygen. (4)

Note: The characteristic gas constant for Oxygen has a value of 260 J/kgK.

$P_1 = 250{,}000\ (\text{Pa})$ $\quad$ $P_2 = 1{,}250{,}000\ (\text{Pa})$

$V_1 = 0.5\text{m}^3$ $\quad$ $V_2 = 0.5\text{m}^3$

$T_1 = 25°\text{C} = 298\ \text{k}$ $\quad$ $T_2 = x$

a) $P_1 V_1 = m R t_1$

$250{,}000 \times 0.5 = x(260)(298)$

$125{,}000 = 77480x$

$$\frac{125{,}000}{77480} = x$$

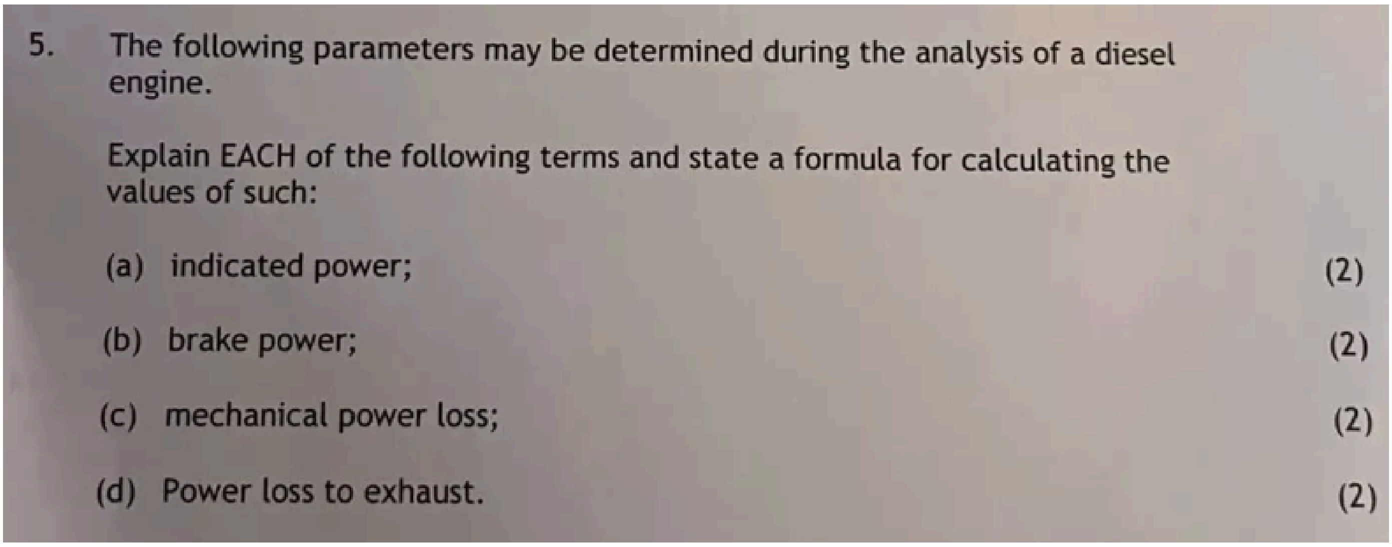
$\boxed{1.61332\ \text{kg}}$

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

$$\frac{250{,}000}{298} = \frac{1{,}250{,}000}{x}$$

$$838.926 = \frac{1{,}250{,}000}{x}$$

$x = \boxed{1490\ \text{k}}$



5. The following parameters may be determined during the analysis of a diesel engine.

Explain EACH of the following terms and state a formula for calculating the values of such:

(a) indicated power; (2)

(b) brake power; (2)

(c) mechanical power loss; (2)

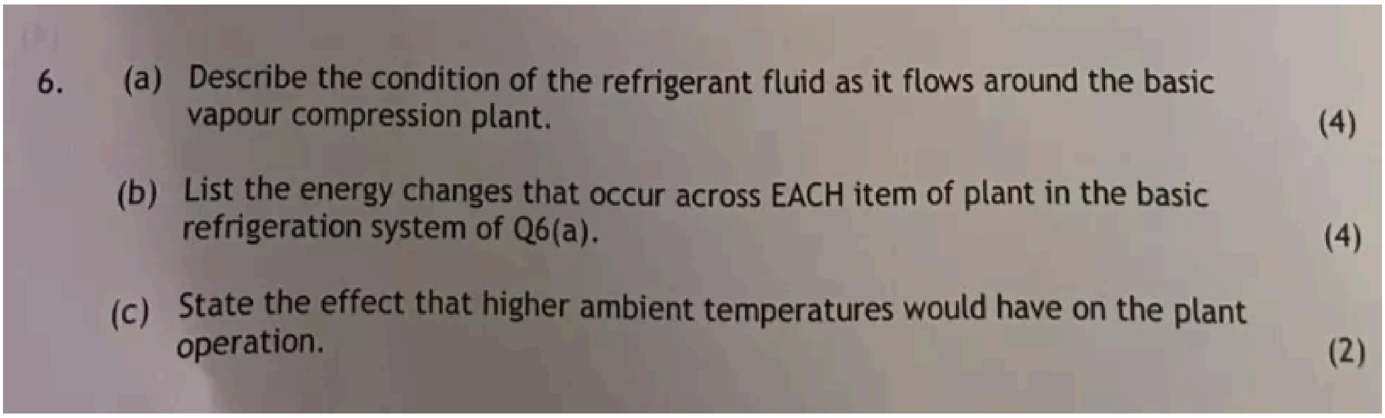
(d) Power loss to exhaust. (2)

a)

b)

c)

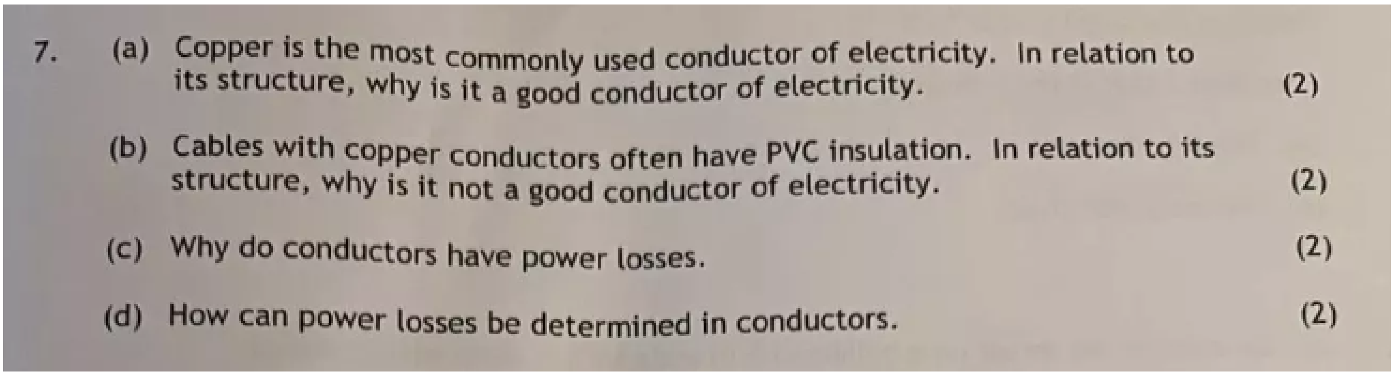
d)



6. (a) Describe the condition of the refrigerant fluid as it flows around the basic vapour compression plant. (4)

(b) List the energy changes that occur across EACH item of plant in the basic refrigeration system of Q6(a). (4)

(c) State the effect that higher ambient temperatures would have on the plant operation. (2)



7. (a) Copper is the most commonly used conductor of electricity. In relation to its structure, why is it a good conductor of electricity. (2)

(b) Cables with copper conductors often have PVC insulation. In relation to its structure, why is it not a good conductor of electricity. (2)

(c) Why do conductors have power losses. (2)

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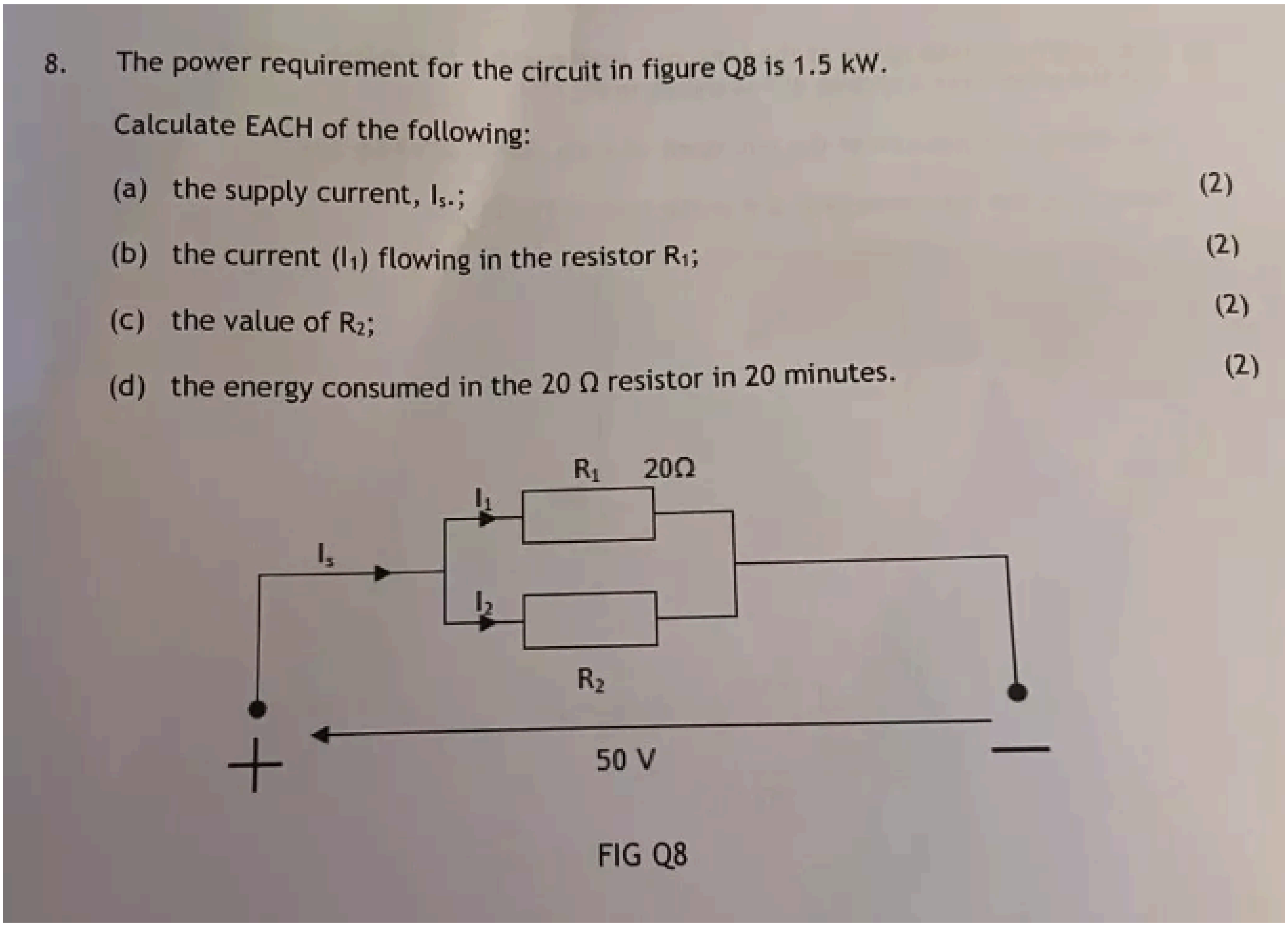


8. The power requirement for the circuit in figure Q8 is 1.5 kW.

Calculate EACH of the following:

(a) the supply current, I_s.; (2)

(b) the current (I_1) flowing in the resistor R_1; (2)

(c) the value of R_2; (2)

(d) the energy consumed in the 20 Ω resistor in 20 minutes. (2)

FIG Q8

a) $P = IV$

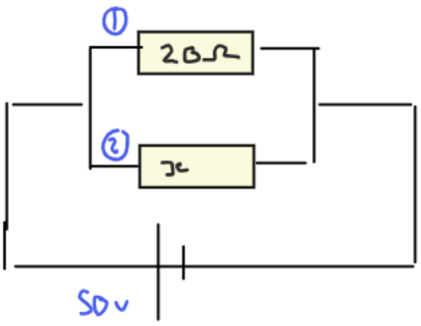
$1500 = x \times 50$

$\frac{1500}{50} = x$

$\boxed{30A} = x$

Supply current

b)



Amps in R_1

$V = 50$

$I = 2.5 \text{Amps}$

$R = 20$

$I = \frac{V}{R} = \frac{50}{20} = 2.5A$

c) Amps in R2

total Amps $= I_1 + I_2$

$30 = 2.5 + x$

$I_2 = 27.5$ Amps

find the res

$V = 50$

$I = 27.5$

$\boxed{R = 1.818181 \Omega}$

$R = \frac{V}{I} = \frac{50}{27.5}$

$R = 1.818191 \Omega$

d) Energy in kwh

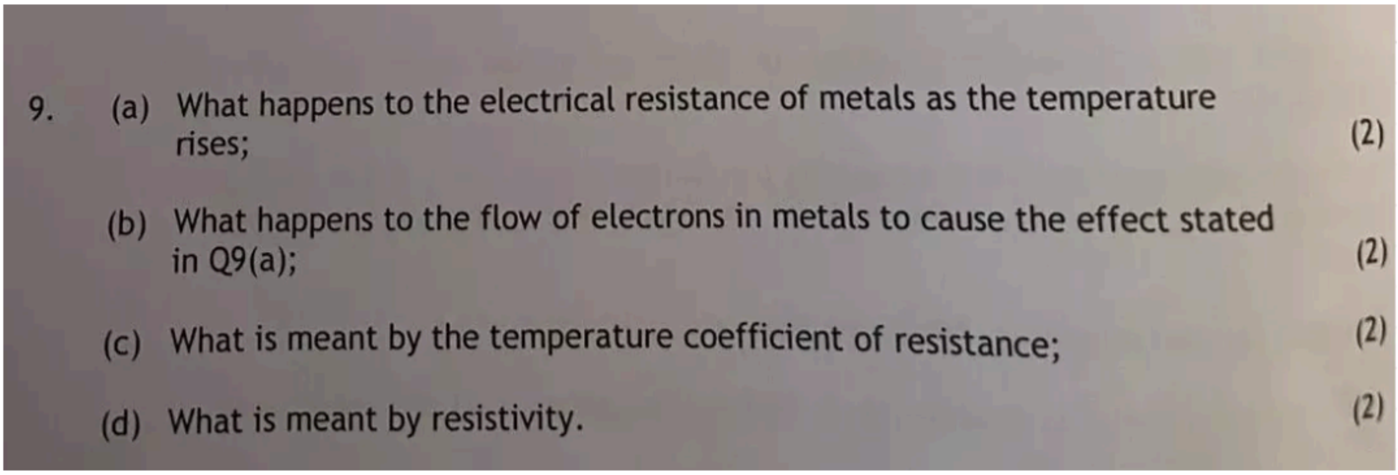
$P_2 = I_2 V_2$

$27.5 \times 50 = 1375$ watts

1.375 kw

$\frac{20 \text{mins}}{60} = \frac{1}{3}$ hour $= 0.3333$

$0.33333 \times 1.375 \text{kw} = \boxed{0.45833 \text{ kwh}}$



9. (a) What happens to the electrical resistance of metals as the temperature rises; (2)

(b) What happens to the flow of electrons in metals to cause the effect stated in Q9(a); (2)

(c) What is meant by the temperature coefficient of resistance; (2)

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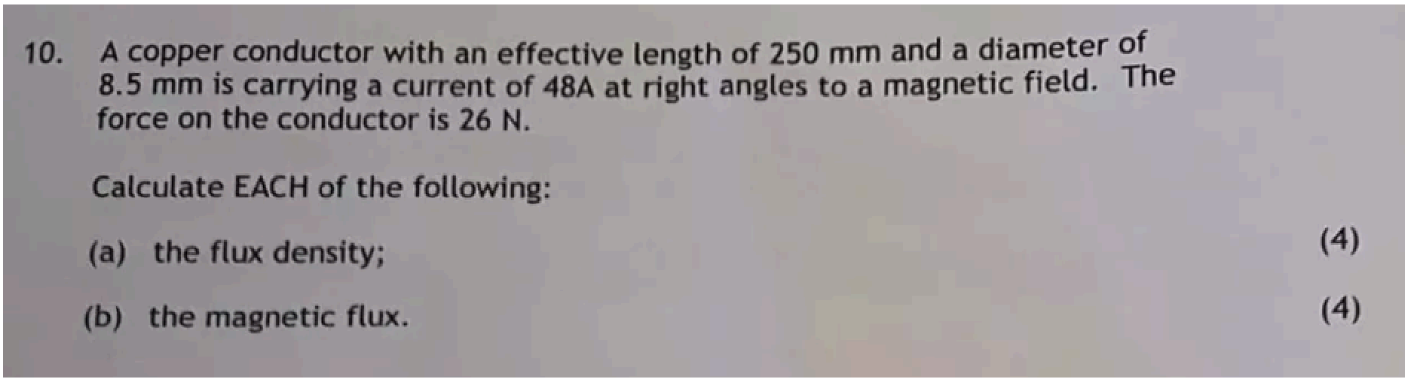


10. A copper conductor with an effective length of 250 mm and a diameter of 8.5 mm is carrying a current of 48A at right angles to a magnetic field. The force on the conductor is 26 N.

Calculate EACH of the following:

(a) the flux density; (4)

(b) the magnetic flux. (4)

a) $F = BIL\cancel{\sin\theta}$

$F = 26N$

$B = x$

$I = 48A$

$L = 0.25m$

$26 = x(48)(0.25)$

$26 = 12x$

$\frac{26}{12} = x$

$\boxed{2.1666 \text{ Tesla}}$

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

$B = 2.16667$ (Tesla)

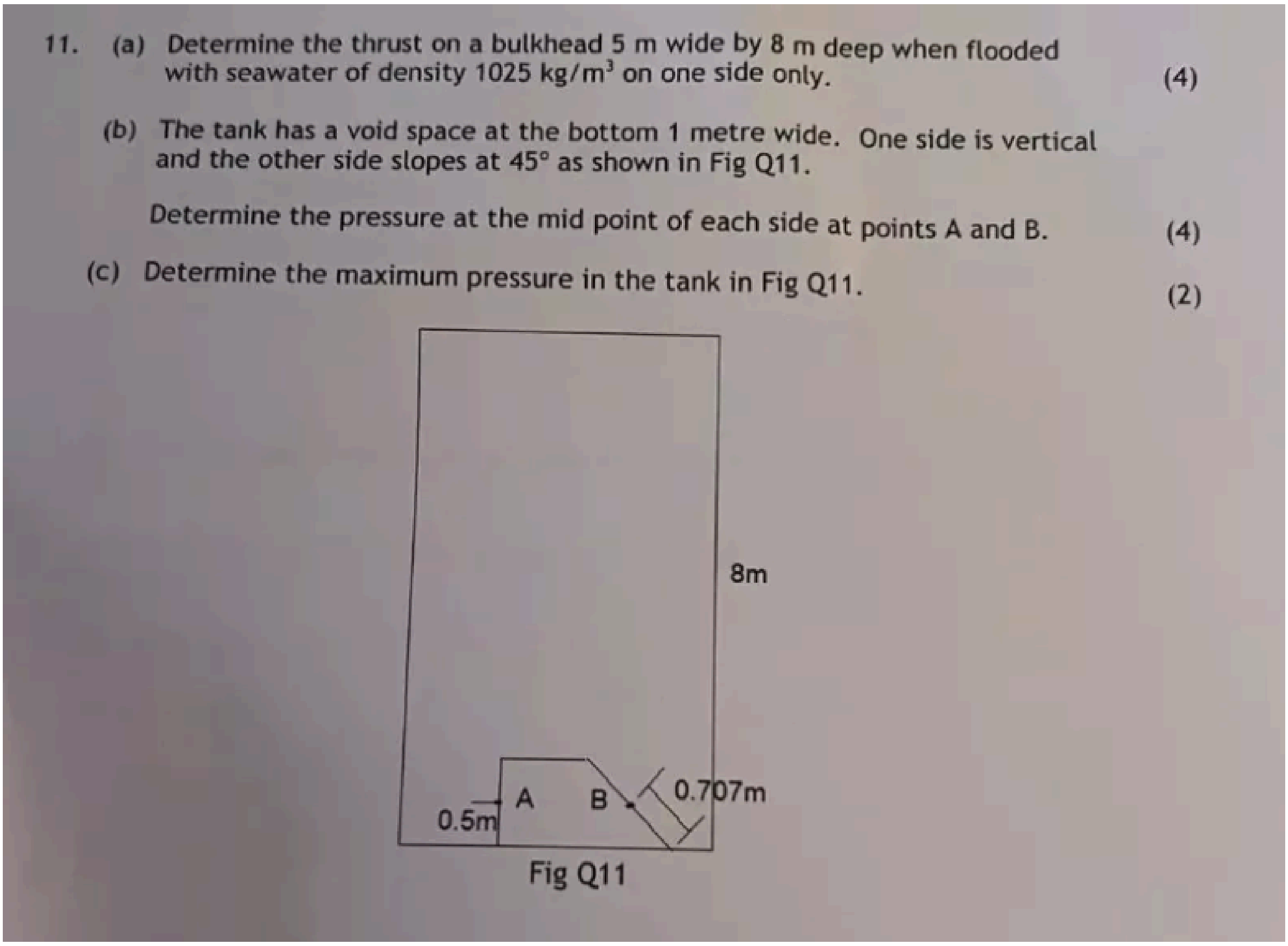
$\phi = x$

$A = \left(\frac{8.5}{2000}\right)^2 \pi = 5.6745 \times 10^{-5} m^2$

$BA = \phi$

$2.16666 \times 5.6745 \times 10^{-5} = \phi$

$\boxed{1.22947 \times 10^{-4} \text{ wb}}$



11. (a) Determine the thrust on a bulkhead 5 m wide by 8 m deep when flooded with seawater of density 1025 kg/m^3 on one side only. (4)

(b) The tank has a void space at the bottom 1 metre wide. One side is vertical and the other side slopes at 45° as shown in Fig Q11.

Determine the pressure at the mid point of each side at points A and B. (4)

(c) Determine the maximum pressure in the tank in Fig Q11. (2)

Fig Q11

a)

$F = \rho g A h$

$\rho = 1025$

$g = 9.81$

$A = (8 \times 5) = 40$

$h = 4m$

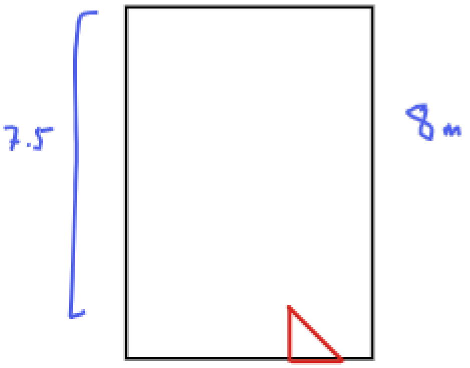
$F = 1025 \times 9.81 \times 40 \times 4$

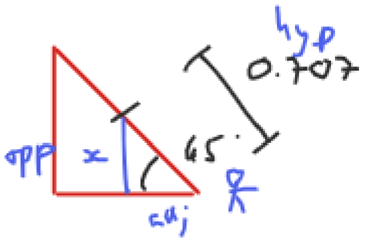
$\boxed{F = 1{,}608{,}840N}$

b) $P = \rho g h$

$P_A = 1025 \times 9.81 \times 7.5$

$= 75414.375$ (Pa)





SOH

CAH

TOA

$\sin(45) = \frac{x}{0.707}$

$0.707 \sin 45 = x$

$0.4999 = x$

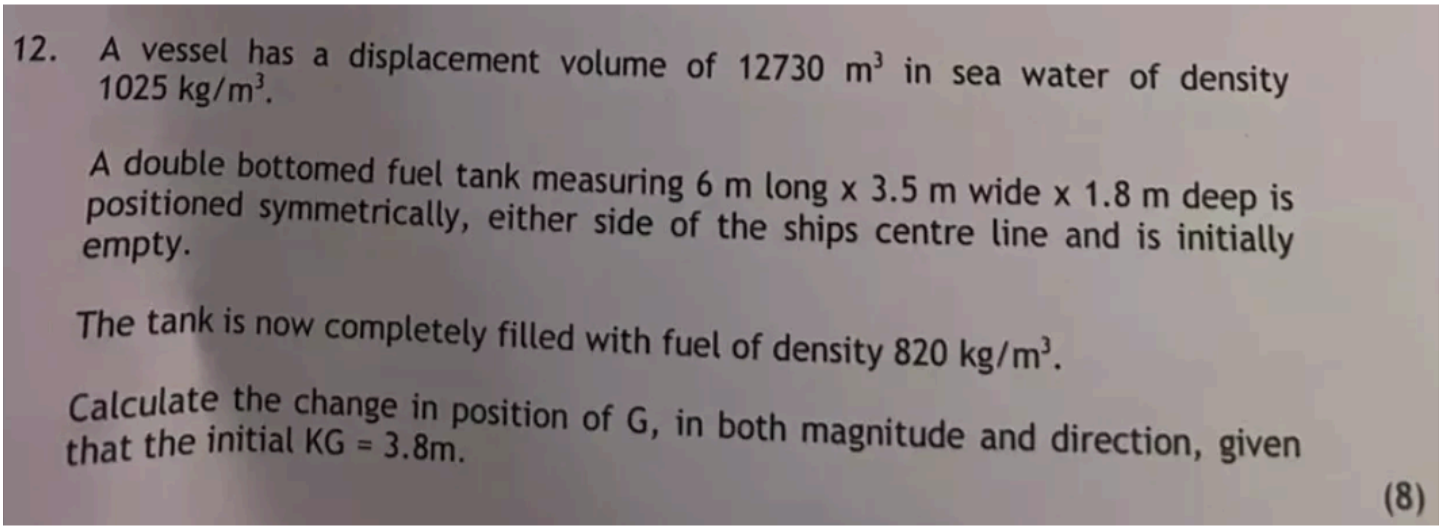
$0.5 = x$

pressure at point A is the same at point B

c) max pressure $= \rho g h$

$1025 \times 9.81 \times 8$

80,442 (Pa)



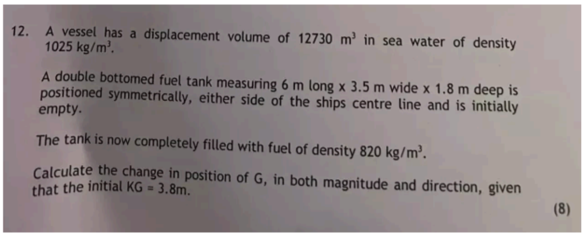
12. A vessel has a displacement volume of 12730 m³ in sea water of density 1025 kg/m³.

A double bottomed fuel tank measuring 6 m long x 3.5 m wide x 1.8 m deep is positioned symmetrically, either side of the ships centre line and is initially empty.

The tank is now completely filled with fuel of density 820 kg/m³.

Calculate the change in position of G, in both magnitude and direction, given that the initial KG = 3.8m.

(8)



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The tank is now completely filled with fuel of density 820 kg/m³.

Calculate the change in position of G, in both magnitude and direction, given that the initial KG = 3.8m.

(8)

mass ship $\frac{m}{d \; v}$

$m = 1.025 \times 12730$

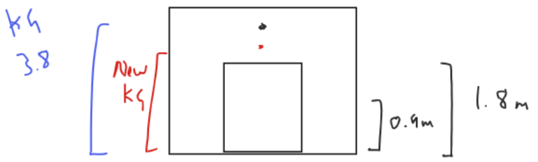
$= 13048.25$ t

mass load

$m = 0.820(6 \times 3.5 \times 1.8)$

$0.82 \times (37.8)$

30.996 t



Name	Mass (t)	Dis (m)	Moment (t m)	Dir A/C
Ship	13048.25	3.8	49,583.35	C
load	30.996	0.9	27.8964	C
Ship+load	13079.246	x	13079.246x	A

Sum of the clockwise moments = Sum of the anticlockwise moments

Sum of the clockwise moments = Sum of the anticlockwise moments

$$49{,}583.35 + 27.8964 = 13079.246x$$

$$49611.3964 = 13079.246x$$

$$\frac{49611.3964}{13079.246} = x$$

$$3.793138871 \text{ m} = \text{New KG}$$

$$\underline{\Delta kg} = 3.8 - 3.793138871$$

so small !

$$\boxed{0.006861129 \text{ m}} = 6.86 \text{ mm}$$

Keelwards