higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T570(E)(J30)T
AUGUST EXAMINATION

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N3

(15070413)

30 July 2014 (Y-Paper)
13:00–16:00

REQUIREMENTS: Properties of water and steam (BOE-173)

Calculators may be used.

This question paper consists of 8 pages, 2 formula sheets and 1 information sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. All the calculations should consist of at least the THREE steps:
   - 4.1 The formula used or manipulation thereof
   - 4.2 Substitution of the given data in the formula
   - 4.3 The answer with the correct SI unit
5. Drawing instruments must be used for all drawings/diagrams.
6. ALL drawings/diagrams must be fully labelled.
7. The constant values, as they appear on the attached information sheet, must be used wherever possible.
8. Keep subsections of questions together.
9. Start each question on a NEW page.
10. Use $g = 9{,}8\ m/s^2$
11. Answers must be rounded off to THREE decimal places.
12. Write neatly and legibly.

QUESTION 1: MOTION, POWER AND ENERGY

1.1 FIGURE 1 below shows a graph of velocity against time. Use the graph to calculate the following:

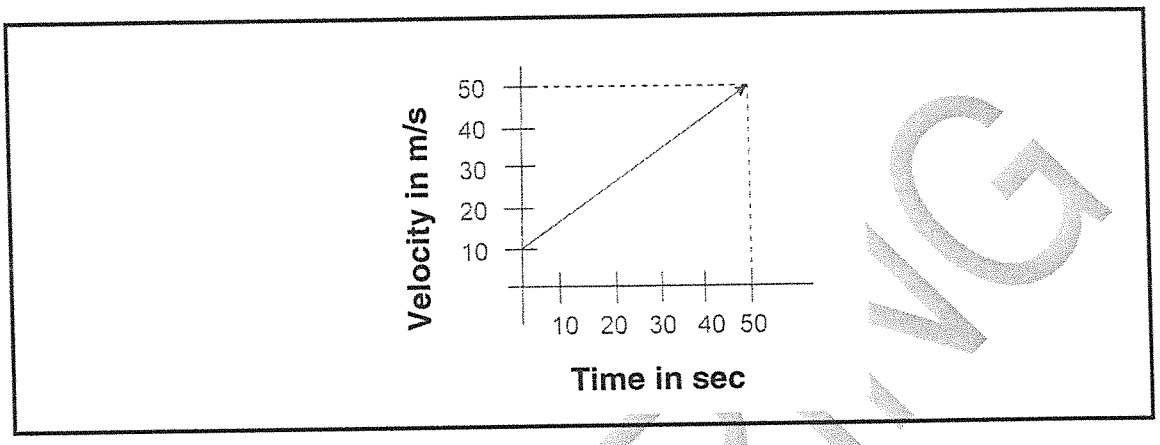

FIGURE 1

1.1.1 The acceleration (2)

1.1.2 The initial velocity (1)

1.1.3 The total displacement (2)

1.2 A tower is 24 m high. A stone is projected upwards from the tower with an initial velocity of 24, 5 m/s.

Calculate how long it would take for the stone to reach the ground at the foot of the tower. (4)

1.3 Describe the following terms: (3)

1.3.1 force (2)

1.3.2 mass. (1)

1.4 A cannon with a mass of 10 tons fires a bullet horizontally with a mass of 50 kg. The velocity of the bullet when it leaves the barrel of the cannon is 800 m/s.

Calculate the recoil velocity of the cannon. (3)
[15]

QUESTION 2: MOMENTS

2.1 Describe what you understand by *shear force*. (2)

2.2 FIGURE 2 below shows the shear-force diagram of a horizontal beam of a uniform cross section being supported at two positions.

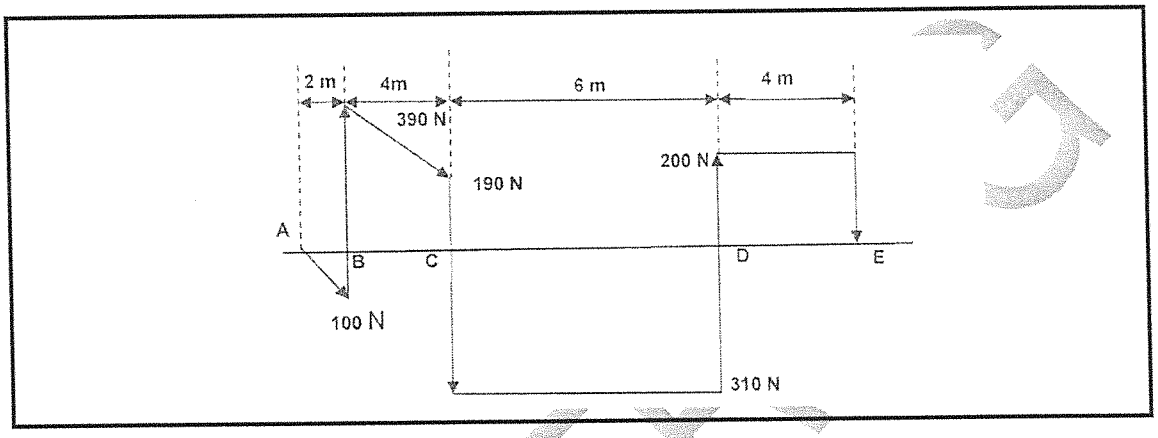

FIGURE 2

2.2.1 At which TWO positions is the beam supported and what is the magnitude of each support? (2)

2.2.2 Calculate the magnitude of the distributed load per meter length. (2)

2.3 FIGURE 3 below shows a light horizontal beam ABCD with a uniform cross section loaded as shown. The magnitude of support A is 32,222 kN.

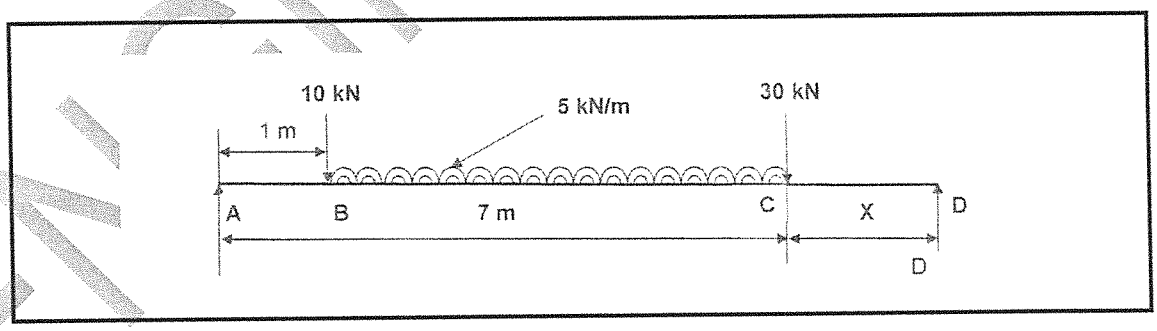

FIGURE 3

2.3.1 Calculate the magnitude of support D by using Newton's third law. (4)

2.3.2 Calculate the distance X by taking moments about support D. (4)
[14]

QUESTION 3: FORCES

3.1 Define the *triangle of forces.* (2)

3.2 Determine analytically the magnitude and direction of the resultant of the system of forces shown in FIGURE 4 below.

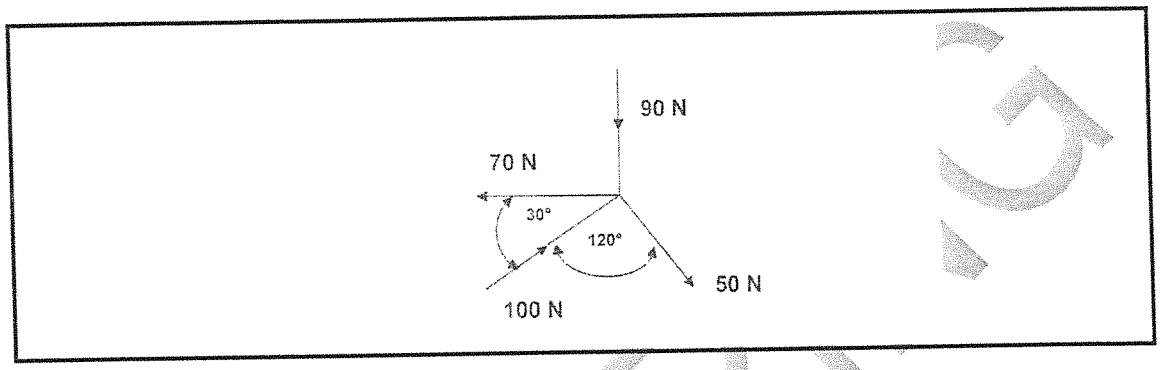

FIGURE 4 (8)

3.3 FIGURE 5 below shows a structure. Determine graphically or calculate the magnitude and nature of the forces in members PQ and PR.

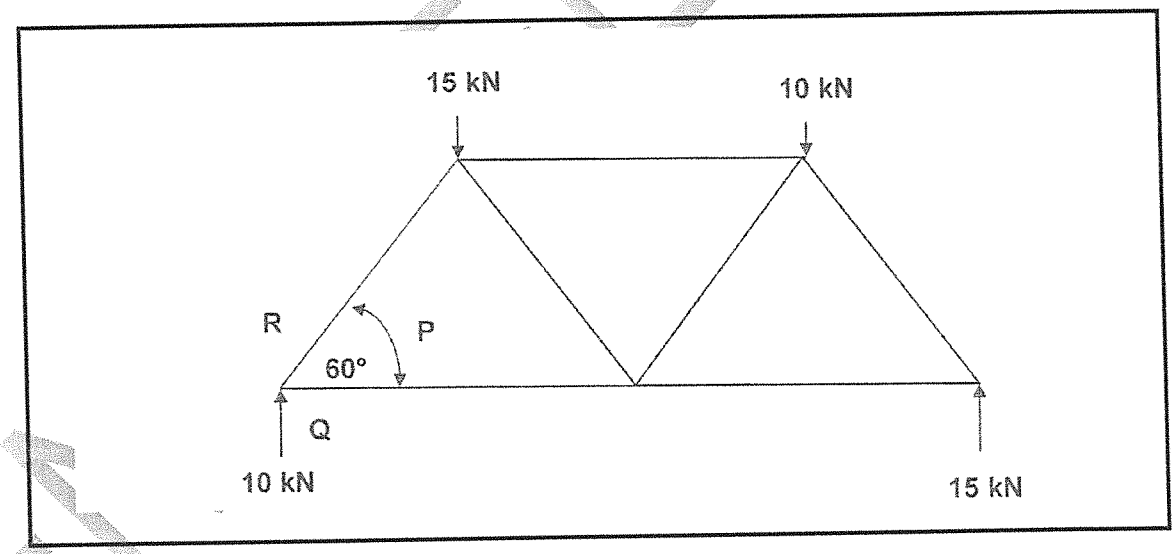

FIGURE 5 (4)
[14]

QUESTION 4: FRICTION

4.1 List FOUR advantages of friction. (4)

4.2 A block with a mass of 0,75 ton rests on an inclined plane at an angle of 20° to the horizontal plane.

If the friction force is 2 000 N, determine the following:

4.2.1 The component of the weight of the block parallel with the plane. (2)

4.2.2 The component of the weight of the block perpendicular to the plane. (2)

4.2.3 The smallest force required to pull the block upwards along the plane. (2)

4.2.4 The coefficient of friction. (2)

[12]

QUESTION 5: HEAT

5.1 Explain the term *heat value of a fuel.* (2)

5.2 Name THREE of the factors we have to take into account when we want to heat or cool something. (3)

5.3 5 kg of steel is immersed in water at 20^0C.

What mass of water is required if the final temperature is 40^0C? (5)

5.4 A volume of 250 ℓ of water is heated from 280^0 C to 360^0C by burning coal.

Calculate the following:

5.4.1 The change in temperature of the water (1)

5.4.2 The quantity of heat required (2)

5.4.3 The quantity of coal required (2)

[15]

QUESTION 6: HYDRAULICS

6.1 Explain the following terms:
- Absolute pressure
- Gauge pressure

(3)

6.2 The ram of a hydraulic jack is 100 mm in diameter. The diameter and stroke of the plunger are 20 mm and 50 mm respectively.
Determine the following:

6.2.1 The force that must be applied to the lever to lift a load of 2,3 tons if the efficiency is 85%. (3)

6.2.2 The number of strokes of the lever to lift the load 126 mm. (3)

6.3 The following data were given: An inside diameter of the water pipe is 50 mm and an effective head is 30 m.

Calculate the work done. (3)
[12]

QUESTION 7: ELECTRICITY

7.1 Four cells each having an emf of 1,5 V and an internal resistance of 0,5 Ω are connected in series. Two resistors of 6 Ω and 8 Ω respectively are connected in parallel and then across the terminals of the battery.

Calculate the following:

7.1.1 The current through each cell (3)

7.1.2 The terminal voltage of the battery (2)

7.1.3 The current through each resistor (2)

7.1.4 The internal voltage drop (2)

7.2 Define the term *ampere.* (2)

7.3 Define the term *potential difference.* (1)
[12]

QUESTION 8: CHEMISTRY

8.1 Name THREE known metals that are listed on the periodic chart. (3)

8.2 Complete the following sentences by filling in the missing word(s). Write only the word(s) next to the question number (8.2.1–8.2.3) in the ANSWER BOOK.

Some researchers use the following terms: dry corrosion process instead of (8.2.1) … and wet corrosion process instead of (8.2.2) …

Oxidation of a metal produces a (8.2.3) … (3)
[6]

TOTAL: 100

-1-

ENGINEERING SCIENCE N3

FORMULA SHEET

All the formulae needed are not necessarily included.
Any applicable formula may also be used.

$W = F.s$

$W = \rho.V$

$P = \frac{W}{t}$

$\eta = \frac{Uitset/Output}{Inset/Input}\ 100\%$

$F = m.a$

$\mu = \frac{F_\mu}{N_R}$

$\mu = \tan\Phi$

$N_R = F_C \pm F_T sin\alpha \ldots a = 0$

$F_S = wsin\theta$

$F_C = wcos\theta$

$F_T cos\alpha = F_\mu \pm F_S \ldots a = 0$

$F_e = T_1 - T_2$

$\frac{T_1}{T_2} = tension\ ratio$

$P = F_e . v$

$v = \pi . d . n \ldots n = \frac{N}{60}$

$W_\mu = F_\mu . s$

$\Delta E_p = m.g.\Delta h$

$\Delta E_K = \frac{1}{2}.m.\Delta v^2$

$Q = I^2 . R . t$

$m = I . z . t$

$m_1.u_1 \pm m_2.u_2 = m_1.v_1 \pm m_2.v_2$

$D_e = (D + t)$

$h_{nat/wet} = h_f + x.h_{fg}$

$P = 2.\pi.T.n \ldots T = F.r$

$P = \frac{F_{RAM}}{A_{RAM}} = \frac{F_{PL}}{A_{PL}} \ldots A = \frac{\pi D^2}{4}$

$V_{RAM} = V_{PL} \times n$

$A_{RAM} . H_{RAM} = A_{PL} . L_{PL}$

$F_X = Fcos\theta$

$F_Y = Fsin\theta$

$\Sigma F_X = F_1 cos\theta_1 + \ldots + F_n cos\theta_n$

$\Sigma F_y = F_1 sin\theta_1 + \ldots + F_n sin\theta_n$

$R = \sqrt{\Sigma F_X^2 + \Sigma F_Y^2}$

$tan\varphi = \frac{\Sigma F_Y}{\Sigma F_X}$

$Q = m . c . \Delta t \ldots t_F = to \pm \Delta t$

$m.ww = Q = m.hv$

$P = \frac{Q}{t}$

$\Delta L = Lo . \alpha . \Delta t \ldots L_f = Lo \pm \Delta L$

$\Delta A = A_0 . \beta . \Delta t \ldots A_f = A_0 \pm \Delta A$

$2.a.s = v^2 - u^2$

$s = u.t + \frac{1}{2}.a.t^2$

$v = u + a.t$

$$\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$$

$$M = F \,.\, \perp s$$

$$\Sigma\ CWM = \Sigma ACWM$$

$$P_{ABS} = P_{ATM} + P_{MET}$$

$$P = \delta \times g \times h$$

$$\frac{1}{R_{PAR}} = \frac{1}{R_1} + \ldots + \frac{1}{R_n}$$

$$R_{SER} = R_1 + \ldots R_n$$

$$V_1 - V_2 = -e(U_1 - U_2)$$

$$V = I \times R$$

INFORMATION SHEET

PHYSICAL CONSTANTS

QUANTITY	CONSTANTS KONSTANTE	HOEVEELHEID
Atmospheric pressure	101,3 kPa	Atmosferiese druk
Density of copper	8 900 kg/m^3	Digtheid van koper
Density of aluminium	2 770 kg/m^3	Digtheid van aluminium
Density of gold	19 000 kg/m^3	Digtheid van goud
Density of alcohol (ethyl)	790 kg/m^3	Digtheid van alcohol (etiel)
Density of mercury	13 600 kg/m^3	Digtheid van kwik
Density of platinum	21 500 kg/m^3	Digtheid van platina
Density of water	1 000 kg/m^3	Digtheid van water
Density of mineral oil	920 kg/m^3	Digtheid van minerale olie
Density of air	1,05 kg/m^3	Digtheid van lug
Electrochemical equivalent of silver	1,118 mg/C	Elektrochemiese ekwivalent van silwer
Electrochemical equivalent of copper	0,329 mg/C	Elektrochemiese ekwivalent van koper
Gravitational acceleration	9,8 m/s^2	Swaartekragversnelling
Heat value of coal	30 MJ/kg	Warmtewaarde van steenkool
Heat value of anthracite	35 MJ/kg	Warmtewaarde van antrasiet
Heat value of petrol	45 MJ/kg	Warmtewaarde van petrol
Heat value of hydrogen	140 MJ/kg	Warmtewaarde van waterstof
Linear coefficient of expansion of copper	17 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van koper
Linear coefficient of expansion of aluminium	23 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van aluminium
Linear coefficient of expansion of steel	12 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van staal
Linear coefficient of expansion of lead	54 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van lood
Specific heat capacity of steam	2 100 J/kg.°C	Spesifieke warmtekapasiteit van stoom
Specific heat capacity of water	4 187 J/kg.°C	Spesifieke warmtekapasiteit van water
Specific heat capacity of aluminium	900 J/kg.°C	Spesifieke warmtekapasiteit van aluminium
Specific heat capacity of oil	2 000 J/kg.°C	Spesifieke warmtekapasiteit van olie
Specific heat capacity of steel	500 J/kg.°C	Spesifieke warmtekapasiteit van staal
Specific heat capacity of copper	390 J/kg.°C	Spesifieke warmtekapasiteit van koper

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MARKING GUIDELINE

NATIONAL CERTIFICATE

AUGUST EXAMINATION

ENGINEERING SCIENCE N3

30 JULY 2014

This marking guideline consists of 9 pages.

QUESTION 1: MOTION, POWER AND ENERGY

1.1 1.1.1 $a = \frac{v-u}{t}$

$= \frac{50-10}{50-0}$

$= 0{,}8\ m/s^2$ ✓ (2)

1.1.2 10 m/s ✓ (1)

1.1.3 μ = 50 m/s

or

(50 x 10) + (0.5 x 50 x 40) ✓

$= 500 + 1\,000$

$= 1\,500\ m$ ✓ (2)

1.2 V = u + gt

$t = \frac{V-\mu}{-g} = \frac{0-24{,}5}{-9{,}8}$

= 2,5 s ✓

$S = ut + ½\ at^2$

$= 35{,}5 \times (2{,}5) + ½\ (-9{,}8)\ (25)^2$

= 61,25 - 30,625

= 30,62 s ✓

$S = \mu t + ½\ gt^2$

$(30{,}625 + 24) = + ½\ gt^2$

$t = \sqrt{\frac{54{,}625 \times 2}{9{,}8}}$

t = 3,339 s ✓

Total time = 2,5 + 3,339

= 5,839 s ✓ (4)

1.3

1.3.1 Force is that influence which changes✓ or tends to change the state of rest of a body. ✓ (2)

1.3.2 Mass of object is the quantity of matter a body contains. ✓ (1)

1.4 $M_1V_1 = M_2V_2$

10 000 x V_1✓ = 50 x 800 ✓

V = 4 m/s ✓ (3)

[15]

QUESTION 2: MOMENTS

2.1 Shear force can be defined as a force pushing one part of a body in one direction and another part of the body in another direction. (2)

2.2 2.2.1 Rb = 490 N✓
Rd = 510 N✓ (2)

2.2.2 Distributed load = Force/length

= 100/2 ✓

= 50 N/m ✓

Or

$\left(\frac{390-190}{4}\right)$

= 50N/m (2)

2.3 2.3.1 Upward forces = Down forces

$F_{up} = F_{down}$

$F_A + F_D = 10 + (6 \times 5) + 30$ ✓

$32{,}222 + F_D = 10 + 30 + 30$ ✓

$F_D = 37{,}778$ ✓ (4)

2.3.2 Taking moments about A

$32{,}222\ (7 + x) = 10\ (6 + x) + 30\ (3 + x) + 30x$ ✓

$225{,}554 + 32{,}222x = 60 + 10x + 90 + 30x + 30x$ ✓ (4)

$x = 1{,}999 = 2\text{m}$ ✓ **[14]**

QUESTION 3: FORCES

3.1 If three forces acting at a point are in equilibrium they can be represented in magnitude or size and direction✓ by the sides of a triangle taken in order. ✓ (2)

3.2

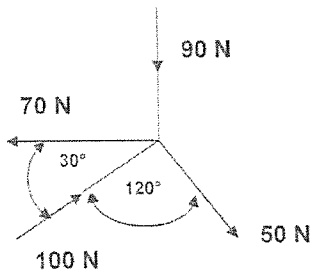
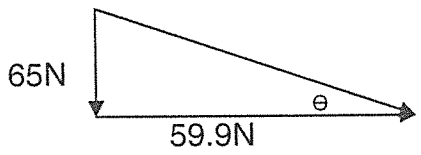


FIGURE 4

EHC = -70 + 100 Cos 30 + 50 Cos 30
= -70 + 86,603 + 43,301 ✓
= +59,904 N ✓ (2)

EVC = -90 – 50 Sin 30 + 100 Sin 30
= -90 – 25 + 50 ✓
= -65 N ✓ (2)



$R = \sqrt{(65)^2 + (59,904)^2}$
R = 88,394 N✓
$\Theta = \text{Tan}^{-1} \frac{65}{59,904}$✓
Θ = 47,336° ✓
R = 88,394N W 47,336° N✓ (4)

3.3 PR = 10/Sin 60^0 ✓

= 11.547 N ✓

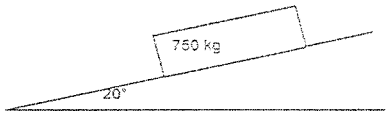
PQ = Cos 60^0 X 11.547 ✓

= 5.774 N ✓ (4)
[14]

QUESTION 4: FRICTION

4.1
- Prevents slip between two contact surfaces✓
- Removes material✓
- Transmits movement by means of belts✓
- Brings movement to a standstill✓ (4)

4.2



Fμ = 2000N

FIGURE 5

4.2.1 The weight component // with the plane
$W\sin\Theta = 750 \times 9{,}8 \times \sin 20$ ✓
$= 2513{,}848$ N✓ (2)

4.2.2 The weight component ⊥ with the plane
$W\cos\Theta = 750 + 9{,}8 \times \cos 20$ ✓
$= 6906{,}741$ N✓ (2)

4.2.3 $Fup = F\mu + W \sin \Theta$
$= 2000 + 2513{,}848$ ✓
$= 4513{,}848$ N✓ (2)

4.2.4 The coefficient of $F\mu = \mu W\cos\Theta$

$$\mu = \frac{F\mu}{W \cos \Theta}$$

$$= \frac{2\,000}{6\,906{,}741}$$ ✓

$= 0{,}289$ ✓

(2)
[12]

QUESTION 5: HEAT

5.1 The heat value of fuel is the quantity of heat released when 1 kg✓ of the substance is completely burnt. ✓ (2)

5.2 Temperature, ✓ mass✓ and specific heat capacity. ✓ (3)

5.3 $Q_{water} = Q_{Steel}$
$M \times C \times \Delta t = M \times C \times \Delta t$
$M \times C (t_2 - t_1) = M \times C \times (t_3 - t_2)$
$M \times 4200 \times (80 - 25) = 0{,}2 \times 30 \times 460 \times (800\text{-}8\text{-}80)$ ✓
$M \times 4200 \times 55 = 6 \times 460 \times 720$ ✓
231 000 m = 1987200 ✓
M = 8,6 kg ✓
1 kg water = 1 ℓ
Volume = 8,6 ℓ ✓ (5)

5.4 250 kg
30 MJ/Kg
280 K
3 360 K

5.4.1 $\Delta t = t_2 - t_1$
$= 360 - 280$
$= 80\ °C$ ✓ (1)

5.4.2 $Q = ,M \times C \times \Delta t$
$Q = 250 \times 4187 \times 80$ ✓
$Q = 83740000\ J$
$Q = 83{,}74\ MJ$ ✓ (2)

5.4.3 $M = \frac{83\ MJ\ kg}{30\ MJ}$ ✓
$M = 2{,}791\ kg$ ✓ (2)
[15]

QUESTION 6: HYDRAULICS

6.1 Absolute pressure is zero-referenced against a perfect vacuum, so it is equal to gauge pressure plus atmospheric pressure.✓

Gauge pressure is zero-referenced against ambient air pressure, ✓so it is equal to absolute pressure minus atmospheric pressure.✓ (3)

6.2 6.2.1 $W = mg = 2\,300 \times 9{,}8$

$$F_p = \frac{Wd^2}{\eta \times D^2}$$

$$= \frac{22\,540(0{,}020)^2}{0{,}85(0{,}1)^2} \quad ✓ \quad ✓$$

$$= 1\,060{,}706\ N \quad ✓$$

(3)

6.2.2 No of strokes = $\frac{D^2 \times \text{height lifted}}{D^2 \times \text{strokes}}$

$= \frac{100^2 \times 126}{20^2 \times 5}$ ✓ ✓

= 63 strokes ✓ (3)

6.3 Θ = 50 mm
H = 30 Work done = volume x p x g x height
Work done = π d^2 x h x p x g x h ✓
= π x $(0{,}05)^2$ x 30 x 1000 x 9,8 x 30 ✓
= 17318 J ✓
= 17,318 kJ (3)
[12]

QUESTION 7: ELECTRICITY

7.1 7.1.1

$$I = \frac{E}{R + r}$$

$$= \frac{6}{3,43 + 2}$$

$= 1,105$ A ✓

$ET = 4 \times 1,5$

$= 6$ V ✓

$r_t = 4 \times 0,5$

$= 2\ \Omega$ ✓

$Rt = ?$

$$= \frac{1}{6} + \frac{1}{8}$$

$$\frac{2}{Rt} = 0,29167$$ ✓

$Rt = 3,43\ \Omega$ ✓ (3)

7.1.2 $V = ?$

$V = E - Ir$

$= 6 - 1,105 \times 2$

$= 3.79$ V

or

$V = I \times R$

$= 1,105 \times 3,43$ ✓

$= 3.79$ V ✓ (2)

7.1.3 $IR1 = \frac{V}{R_1}$

$= \frac{3,79}{6}$ ✓

$= 0,63$ A ✓

$IR_2 = \frac{V}{R_2}$

$= \frac{3,79}{8}$ ✓

$= 0,47$ A ✓ (2)

7.1.4 Vo linternal = Ir internal

$= 1,105 \times 2$ ✓

$= 2.21$ V ✓ (2)

7.2 The ampere is that constant current which if maintained in two straight parallel conductors of infinite length, ✓ of negligible cross section, and placed apart in a vacuum, would produce between these conductors, a force equal to 2×10^{-7} N/m of length. ✓ (2)

7.3 The potential difference is the difference in electric tension at the positive and negative poles of a cell. (1)

[12]

QUESTION 8: CHEMISTRY

8.1
- Iron ✓
- Copper ✓
- Aluminium ✓
- Zinc
- Tin
- Lead
- Gold
- Silver

any three (3)

8.2 8.2.1 Chemical corrosion✓

8.2.2 Electrochemical corrosion✓

8.2.3 Metal oxide✓ (3)
[6]

TOTAL: 100