T570(E)(A2)T

APRIL EXAMINATION

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N3

(15070413)

2 April 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, 1 information sheet and 1 formula sheet of 2 pages.

2. Read ALL the questions carefully.

3. Number the answers according to the numbering system used in this question paper.

4. Answers must be rounded off to THREE decimal places.

5. All the calculations should consist of at least the following THREE steps:

   - The formula used or the manipulation thereof
   - Substitution of the given data in the formula
   - The answer with the correct SI unit

6. Drawing instruments must be used for all drawings/diagrams. All drawings/ diagrams must be fully labelled

7. One mark indicates one percentage point, that is 100 marks = 100%

8. The constant values, as they appear on the attached information sheet, must be used wherever possible.

9. Keep subsections of questions together.

10. Rule off on completion of each question.

11. Use $g = 9{,}8\ m/s^2$

12. Write neatly and legibly.

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called … (1)

1.2 A rope is used to hoist an object with a mass of 1,3 tons vertically through a distance of 100 m. The mass of the rope is 2 kg per metre.

Determine the following:

1.2.1 The total work done (3)

1.2.2 The average tension in the rope (2)

1.2.3 The power used if it takes 2 minutes to hoist the object (2)

1.3 A drilling machine has a V-belt, with a speed of 15 m/s. The driving pulley is driven at a speed of 8 r/s. The tension in the tight side is 3 250 N and the slack side is 1 400 N.

Determine the following:

1.3.1 The power transmitted (2)

1.3.2 The diameter of the driven pulley (2)
[16]

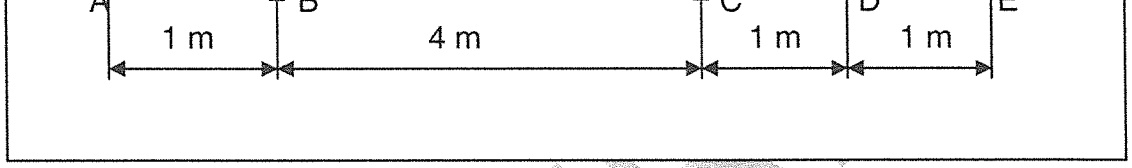


FIGURE 1

2.2.1 Calculate the reaction at the supports and test your answers. (5)

2.2.2 Draw a shear-force diagram, using a suitable scale. Show ALL the main values on the diagram. (4)

[11]

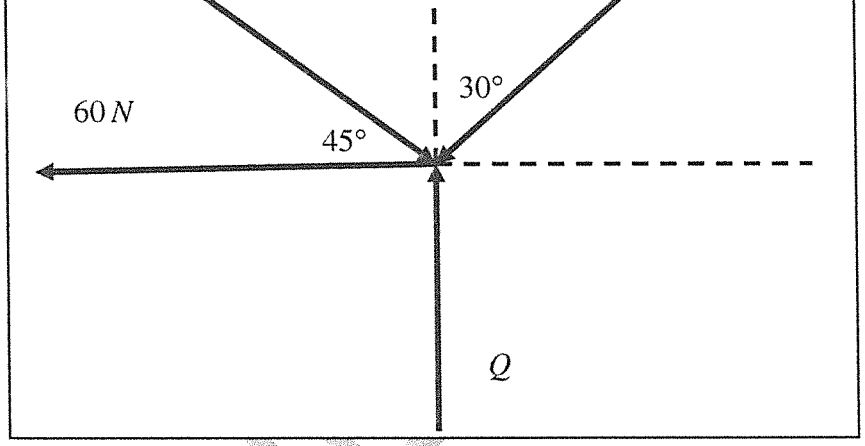


FIGURE 2

3.3 Calculate the magnitude of the unknown force shown in FIGURE 3 below.

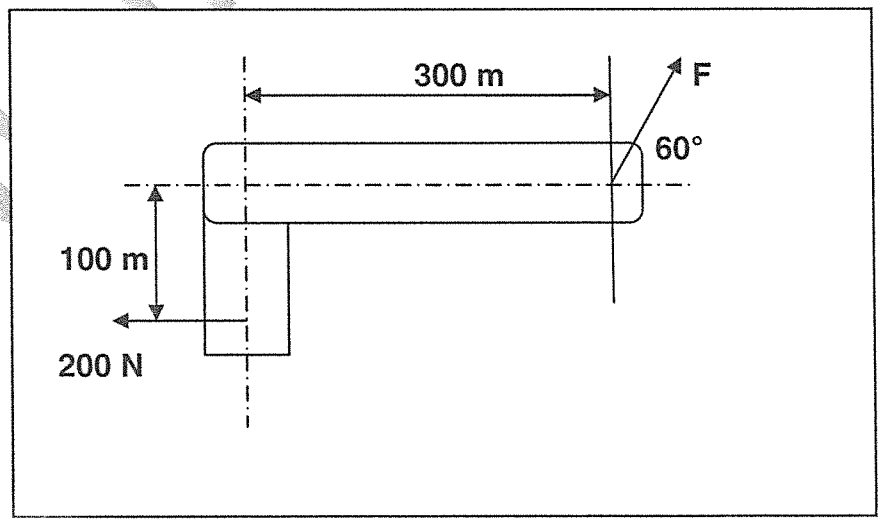


FIGURE 3

(4)
[16]

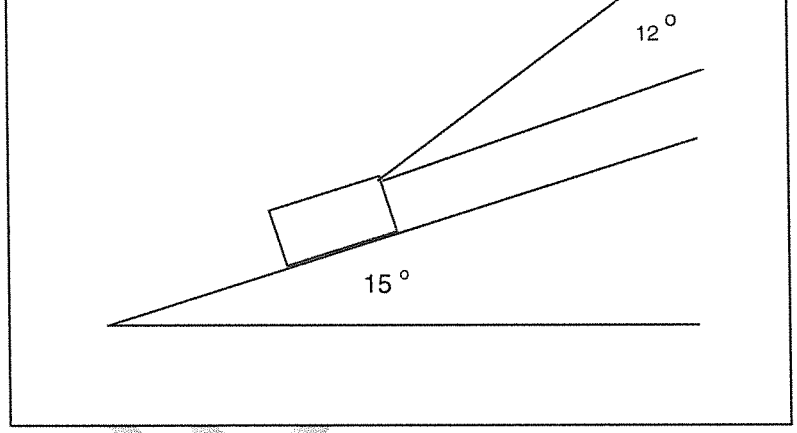


FIGURE 4

(6)
[10]

QUESTION 5: HEAT

5.1 Steel bars with a total mass of 3,5 kg are heated to 217 °C and immediately placed in 28 kg of water at 12 °C.

Determine the final temperature of the steel bars and the water. (4)

5.2 A rectangular brass sheet has a dimension of 450 mm x 350 mm at 10 °C. The coefficient of linear expansion is 20 x 10^{-6}/°C.

If the sheet temperature is raised to 100 °C, determine the following:

5.2.1 The area coefficient of expansion (1)

5.2.2 The increase in area at 100 °C in m^2 (3)

5.2.3 The dimensions at 100 °C (4)

QUESTION 6: HYDRAULICS

6.1 A variety of pumps are being used to pump hydraulic fluids through a system.

Name THREE of these pumps. (3)

6.2 The following information refers to a single-acting hydraulic press:

Diameter of ram	=	55 mm
Force applied to plunger	=	300 N
Diameter of the plunger	=	12 mm
Plunger stroke	=	200 mm

If the mechanical efficiency of the hydraulic system is 80% and that of the lever system is 85%, calculate the following:

6.2.1 The volume of the liquid displaced after 5 pumping strokes of the plunger

6.2.2 The distance in mm that the ram piston will move after 5 pumping strokes

6.2.3 The force exerted by the ram piston

6.2.4 The effort that must be applied to the lever in order to obtain a force of 300 N on the plunger if the mechanical advantage of the lever system is 10

6.2.5 The actual mechanical advantage of the system

(5 × 2) (10)
[13]

Calculate the following:

7.2.1 Its rated current (2)

7.2.2 The resistance of its heating element (2)

7.2.3 The current that it would draw if the supply falls to 200 V (2)

7.2.4 The cost to toast a slice of bread at 220 V if it takes the toaster 2 minutes to toast a slice of bread, and the cost of electricity is R1,64 per unit (3)

[13]

QUESTION 8: CHEMISTRY

8.1 Complete the following sentences by filling in the missing word(s) relating to well-known alloys. Write only the word(s) next to the question number (8.1.1–8.1.3) in the ANSWER BOOK.

… 8.1.1 … is an alloy of steel, vanadium, nickel and molybdenum.

Tool steel is an alloy of …8.1.2 … with high proportions of chrome, molybdenum, vanadium and … 8.1.3 … (3)

8.2 Name THREE properties of brass. (3)

[6]

TOTAL: 100

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

$$F = m.a$$

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

$$\mu = \tan\Phi$$

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

$$F_S = wsin\theta$$

$$F_C = wcos\theta$$

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

$$F_e = T_1 - T_2$$

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

$$P = F_e \,.\, v$$

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

$$W_\mu = F_\mu \,.\, s$$

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

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

$$Q = I^2 \,.\, R \,.\, t$$

$$m = I \,.\, z \,.\, t$$

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

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

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

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

$$F_X = Fcos\theta$$

$$F_Y = Fsin\theta$$

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

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

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

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

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

$$m.ww = Q = m.hv$$

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

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

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

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

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

$$v = u + a.t$$

$$\Sigma \uparrow F = \Sigma \downarrow F$$

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

Please turn over

MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

ENGINEERING SCIENCE N3

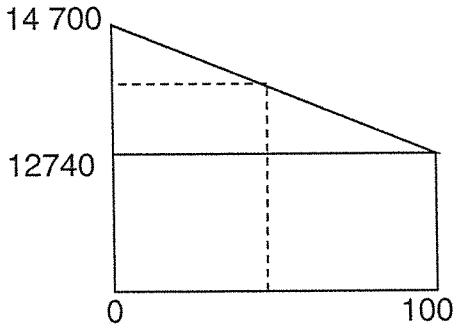
2 APRIL 2014

This marking guideline consists of 11 pages.

1.2 Mo = 1,3 tons = 1300 kg
S = 100 m
Force of object = 1300 x 9.8 = 12740 N

Mr = 2 kg/m = 2x100
= 200 kg

Force in rope = 200 x 9.8 = 1960 N



1.2.1 **WD =** 

= ℓ x b + ½b x h
= 12740 x 100 + ½ x 100 x 1960 ✓
= 1274000 + 98000 ✓
= 1372 000 J or 1372 kJ ✓ (3)

1.2.2 Average = $F_1 + F_2$ OR $\frac{14\,700 + 12\,740}{2}$ ✓

= 1300 x 9.8 + ½ (2x9.8x100) ✓ =13 720 N ✓
= 12 740 + 980 N
= 13 720 N ✓ (2)

1.2.3 Power = $\frac{Wd}{T}$

Power = $\frac{1372\,000}{2\,(60)}$ ✓

Power = 11433,333 W or 11,433 kW ✓ (2)

$\frac{}{N} \quad \frac{}{\pi x 8}$

= 0.597 m

Or 597,75 mm

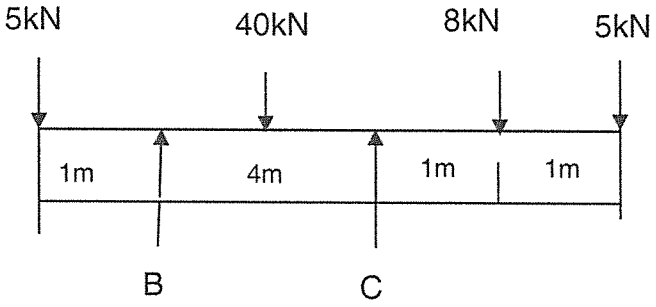
Use 598 mm (2)

[16]

QUESTION 2: MOMENTS

2.1 The moment of a force is the force multiplied by the perpendicular distance from the fulcrum to the line of action of the force. (2)

2.2



2.2.1 Taking moment about B

Sum of the anticlockwise moment = sum of the clock wise moment

Cx4 + 5x1 = 40x2 +8x5+5x6 ✓

Cx4+5=80+40+30

Cx4 = 150 -5

$C=\frac{145}{4}$

C= 36,250 kN ✓

Taking moments about C

Sum of the anticlock wise moments = sum of the clockwise moments.

B x 4 + 8 x 1+ 5 x 2 = 40 x 2 + 5 x 5 ✓

B x + 18 = 80 + 25

B = 21,75 kN ✓

✓

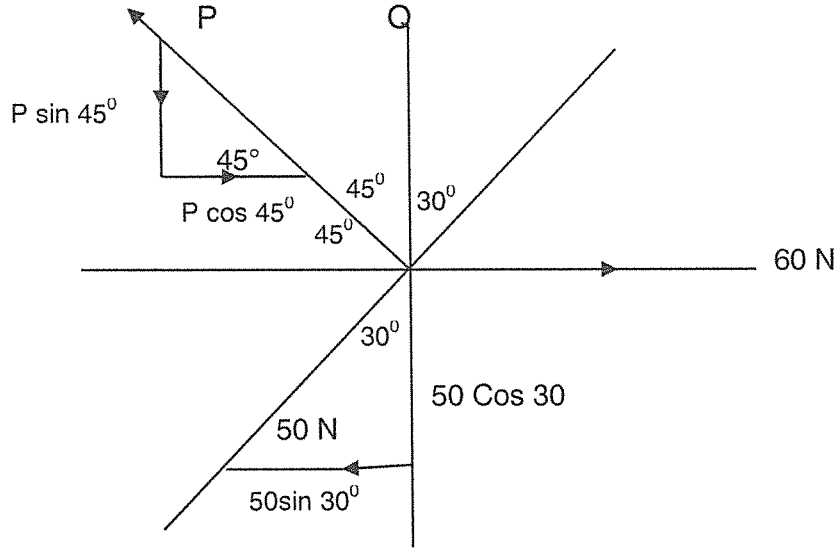
-21.75kN

(4)
[11]

QUESTION 3: FORCES

3.1

- The vectors of the forces form a closed triangle.
- The algebraic sum of the components of the faces in any direction is equal to zero.
- The algebraic sum of the moments of the forces about any point is equal to zero.
- The lines of action of the forces meet a point.
- The forces or vector are co-planar. (5)



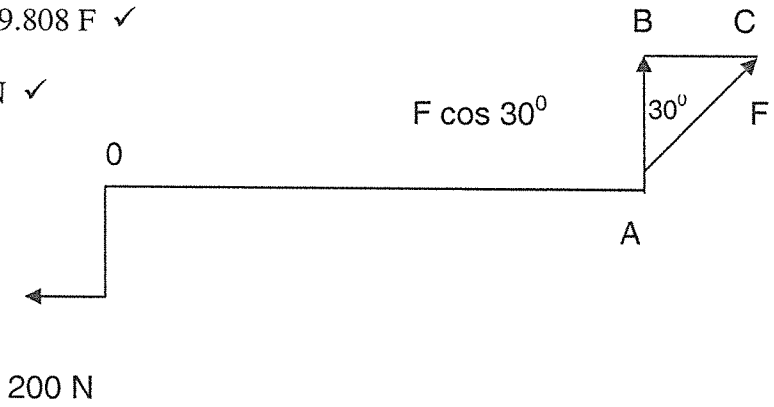
3.3

$\sum$ clockwise moments = $\sum$ anticlockwise moments

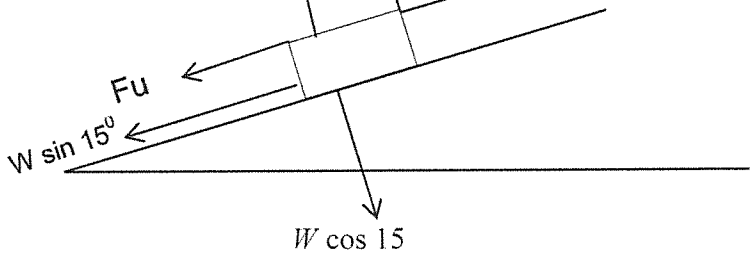
200 x 100 ✓ = 300 x F sin 60^0 ✓

20000 = 259.808 F ✓

F = 76.98 N ✓



(4)
[16]



$\Sigma F_{UP} = \Sigma F_{DOWN}$

$NR + F\sin 12 = W\cos 15$

$NR + F\sin 12 = 600\cos 15$ ..... (1) ✓

$\Sigma F_L = \Sigma F_R$

$F_\mu + w\sin 15 = F\cos 12$

$0{,}2\ NR + 600\sin 15 = F\cos 12$ .....(2) ✓

In (1) $NR = 579{,}556 - F\sin 12$

sub in (2) $0{,}2(579{,}556 - F\sin 12) + 155{,}291 = F\cos 12$ ✓

$115{,}9112 - 0{,}2F\sin 12 + 155{,}291 = F\cos 12$

$271{,}2022 - 0{,}2F\sin 12 = F\cos 12$ ✓

$F(\cos 12 + 0{,}2\sin 12) = 271{,}2022$

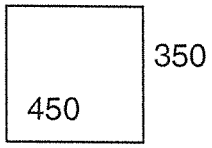
$$F = \frac{271{,}2022}{\cos 12 + 0{,}2\sin 12}$$ ✓

$= 265{,}954\,N$ ✓

(6)
[10]

(4)

5.2



$T_1 = 10\ °C$
$\alpha = 20 \times 10^{-6}$
T2 – 100 °C

5.2.1 1 $\beta = 2 \times \alpha$
$= 2 \times 20 \times 10^{-6}$
$= 40 \times 10^{-6}/°C$ ✓ (1)

5.2.2 The increase in area at 100° C in m^2
$\Delta A = A_0 \times \beta \times \Delta t$
$= (0,45 \times 0,35) \times 40 \times 16^{-6} \times (100 - 10)$ ✓
$= 0,1575 \times 40 \times 10^{-6} \times 90$
$= 5,67 \times 10^{-4}\ m^2$ or $0,000567\ m^2$ ✓
$AF = A_0 + \Delta A = 0,1575 + 0,000567$ ✓
$= 0,158067\ m^2$ (3)

0,45081 | 0,158067

B = 0,1581 / 0,45081

x B = 0,3507 m ✓

(4)

5.3 M = 1 kg
x = 0,94
Pr = 2,5 x 10^6 pa

5.3.1 The liquid at saturated (hf)
2500 kPa
Hf = 962 kJ/kg ✓ (1)

5.3.2 Dry steam
Hg = 2801 kJ/kg ✓ (1)

5.3.3 Evaporate the liquid (hfg)
Hfg = 1839 kJ/kg ✓ (1)
[15]

QUESTION 6: HYDRAULICS

6.1
- Centrifugal✓ (1)
- Rotary✓ (1)
- Reciprocating✓ (1)

D^2 x stroke length x no of strokes = D^2 x stroke length

$0,8x(0,012)^2 \times 0,2x5 = (0,055)^2 \times$ stroke length

$$H = \frac{0,8x(0,012)^2 \times 0,2x5}{(0,055)^2}$$ ✓

✓

$= 0,0380826$ m

$= 38.3$ mm

OR

$V_P = V_R$

$0,000\ 091 = \frac{\pi}{4}(0,055)^2 \times h$

$= 0,0383\ m$

$= 38,3\ mm$ (2)

6.2.3 $\frac{W}{D^2 \times (d)^2} = F$

$$W = \frac{F \times D^2}{d^2}$$

$= \frac{300x\ (0,055)^2}{(0,012)^2}$

$W = 6302,083$ N ✓

Force = W x $\frac{80}{100}$

$= 6302,0873° \times 0,8$ ✓

$= 5041,666$ ° N (2)

$= 8,5$ ✓ (2)

[13]

QUESTION 7: ELECTRICITY

7.1 7.1.1

$$r = \frac{E}{I} - R$$ ✓

$$= \frac{1,48}{0,6} - 2$$

$$= 2,467 - 2$$ ✓

$$= 0,467\,\Omega$$ (2)

7.1.2 $V = E - IR$

$= 1,48 - 0,28$ ✓

$= 1,2\ V$ ✓ (2)

7.2 V = 220 V
P = 1,2 kW

7.2.1 Rated current (I):

$$I = \frac{P}{V}$$

$$= \frac{1,2 \times 10^3}{220}$$ ✓ ✓

= 5,455 A (2)

7.2.2 Resistance (R):

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

$$= \frac{220}{5,455}$$ ✓ ✓

= 40,329 Ω (2)

= 0,0396 kWh ✓

Cost = unit x rate (cost)

=0,0396 x 164 cents

= R6,49 ✓

(3)

[13]

QUESTION 8: CHEMISTRY

8.1 8.1.1 Bright steel ✓

8.1.2 Steel ✓

8.1.3 Tungsten ✓ (3)

8.2 8.2.1 Corrosion resistant ✓

8.2.2 Easily machine-able ✓

8.2.3 Soft ✓ (3)

[6]

TOTAL: 100