higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

PLANT OPERATION THEORY N3

23 November 2022

This marking guideline consists of 6 pages.

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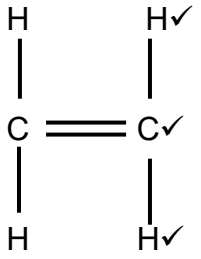
QUESTION 1: CHEMISTRY AND CATALYSTS

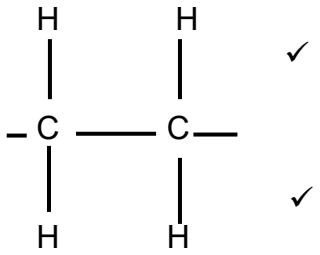
1.1 Thermoplastic polymers soften when heated, harden when cooled down but softens when reheated✓✓, while thermosetting plastics soften when heated, harden when cooled down but will not soften when reheated✓✓.
(Any other 2 × 2) (4)

1.2 1.2.1



(3)

1.2.2



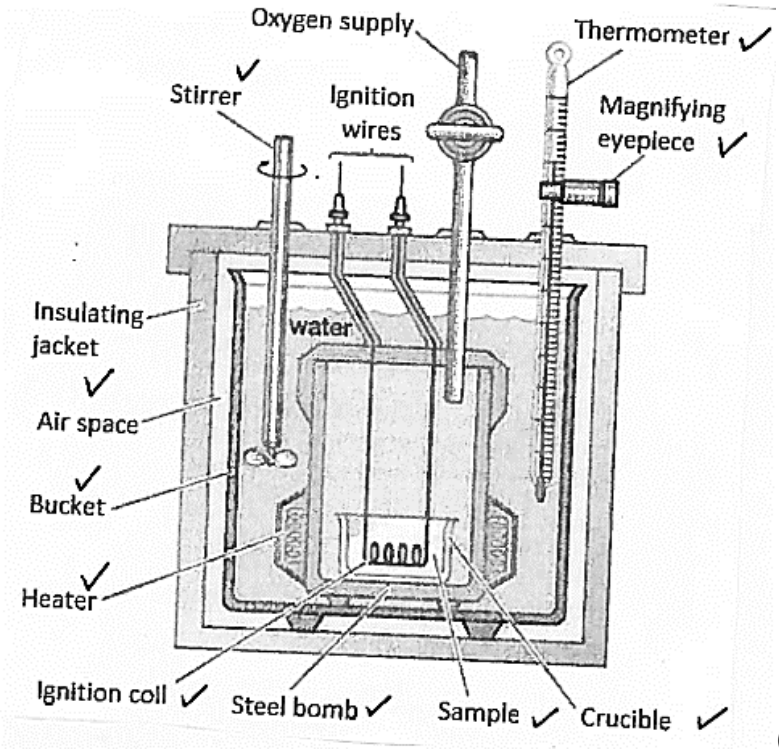
(2)

1.3 The process of forming ammonia from its basic elements is exothermic.✓ Two volumes of nitrogen gas and three volumes of hydrogen gas react over an iron catalyst activated by KOH and Al_2O_3✓ and produce two volumes of ammonia gas.✓ $N_2 + 3H_2$✓⟶ $2NH_3$.✓ The catalyst is sensitive to poison such as H_2S, water vapour and other substances.✓ The catalyst must be purified before feeding it into the reactor. The reaction is enhanced by low temperature and high pressures.✓ High temperature promotes the reverse reaction when NH_3 is broken down into basic components.✓ (Any other 1 × 8) (8)

1.4 Synthesis is the artificial manufacturing of products that are similar in many ways or completely the same as natural products,✓✓ e.g. synthesis of rubber from styrene and butadiene, cellulose from glucose, ammonia from hydrogen and nitrogen and all hydrogenation and dehydrogenation processes.✓ (3)
[20]

QUESTION 2: COMBUSTION, COKING AND GASIFICATION OF COAL

2.1



(Any other 1 × 11) (11)

2.2 2.2.1 Free ash is a deposit material found on the surface where coal is mined.✓ It consists of black shale and sandstone found above and below the seam or layer of coal.✓ It is difficult to separate this material due to large variations in composition, size, shape, quantity and density.✓ It is removed during the washing of the coal.✓

(Any other 1 × 4) (4)

2.2.2 Oxides of sulphur are extremely corrosive✓ and much care is taken to remove these from gases.✓ In blast furnaces these are also disadvantageous as the percentages of sulphur in pig iron is strictly limited.✓ The average content of sulphur in coke is in the region of 0,8%, yet it places great demand on the blast furnace industry.✓

(Any other 1 × 4) (4)

2.3
- There is less loss of heat energy and a higher yield of gas per unit volume of the reactor.✓ ✓
- The costs of compressing the gases are less because only the oxygen✓ instead of all the production gases needs to be compressed.✓
- The high pressure increases heat transfer and the regaining of heat during cooling of the gas.✓ ✓
- The heat value of the gas is higher due to a higher content of methane.✓ ✓

(Any other 2 × 2) (4)

2.4 Fractionation is a process that uses heat to separate a substance into its components. .✓ ✓ (Any other 1 × 2) (2)

[25]

QUESTION 3: HEAT TRANSFER, HEAT EXCHANGER AND THERMAL INSULATION

3.1
- Radiation
- Convection
- Conduction (Any other 2 × 1) (2)

3.2
- Temperature difference
- Time of flow involved
- Thickness of material
- Surface area involved
- Type of material through which heat is transferred (Any other 5 × 1) (5)

3.3
- Gas oil
- Petrol
- LPG
- Kerosine (Any other 1 × 1) (1)

3.4 This type of heat exchanger has a shell or housing consisting of a large-diameter flanged pipe to which a bundle of smaller tubes attached to end plates are bolted or secured✓✓. The cooling and heating mediums are separately passed through the exchanger – one through the shell side and the other through the tube side according to function and circumstances✓✓.
(Any other 2 × 2) (4)

3.5
- Shell
- Tube sheet
- Connections
- Head
- Gaskets
- Mounting
- Baffles
- Tube bundle (Any other 8 × 1) (8)

3.6 The baffle plates fit snugly in the shell of the exchanger prohibiting the liquid to pass between the baffle plates and the shell. (Any other 1 × 2) (2)

[22]

QUESTION 4: PUMPS AND COMPRESSION

4.1 4.1.1 False.✓ The valves are all situated at one end of the cylinder.✓ (2)

4.1.2 False.✓ There are three or more cylinders and pistons.✓ (2)

4.1.3 True.✓ The shape of the plunger is cylindrical and the length of the stroke is adjustable such as that of a piston.✓ (2)

4.1.4 False.✓ It states that at the same temperature and pressure equal volume of all gases contains the same number of molecules.✓ (2)

4.1.5 True.✓ Volume and temperature remain constant.✓ (2)

4.2 $\mathrm{D} = 250\ \mathrm{mm} = 0{,}25\ \mathrm{m}$
$\mathrm{L} = 200\ \mathrm{mm} = 0{,}2\ \mathrm{m}$
$\mathrm{N} = 350\ \mathrm{mm} \times 60\ \mathrm{r/n}$

$V = \frac{\pi d^2}{4} \times L \times N \times 2$
$= \frac{\pi(0{,}25)^2}{4} \times 0{,}2 \times 350 \times 2$✓✓
$= 6{,}872\mathrm{m}^3/\mathrm{min}$✓
$= 412{,}33\mathrm{m}^3/\mathrm{h}$✓ (4)

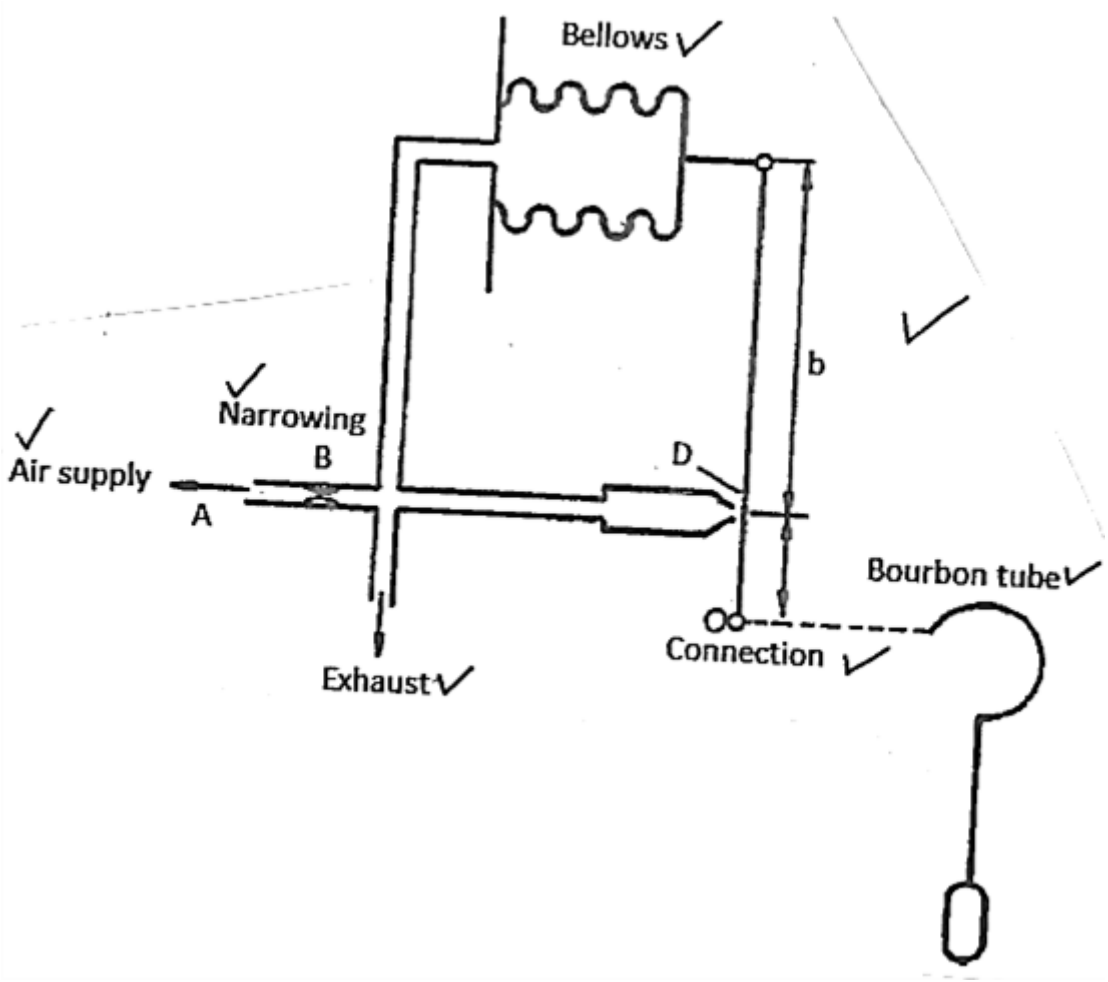
4.3 4.3.1 The differential pressure is very low and it only moves the air or gas. (2)

4.3.2 The suction pressure is higher than the atmospheric pressure. (2)

4.3.3 The suction pressure is from a vacuum pressure lower than atmospheric pressure. (2)
[20]

QUESTION 5: INSTRUMENTATION AND CONTROL SYSTEMS

5.1



(Any other 1 × 7) (7)

5.2	5.2.1	Automatic control action	(2)
	5.2.2	Rate or derivate action	(2)
	5.2.3	Pneumatic transmitter	(2)
			[13]

TOTAL: 100

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