higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

PLANT OPERATION THEORY N3

31 JULY 2018

This marking guideline consists of 6 pages.

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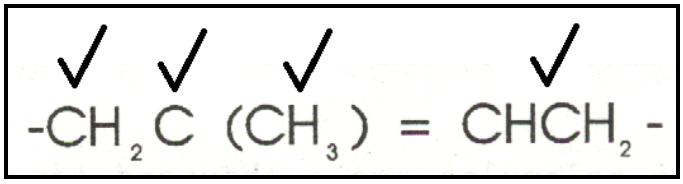
QUESTION 1

1.1
- Chain reaction of atoms within the reacting molecule
- Rearrangement of atoms in all the reacting molecules without loss of atoms (monomer and polymer)
- A ring bond of atoms splitting and bonding with another ring bond (molecule) with the aid of a catalyst (3)

1.2 It is the reaction of solid fuel or coal with air, O_2, steam, and CO_2 or a mixture of these gases✓ to produce gaseous products that can be used as an energy source.✓ (2)

1.3

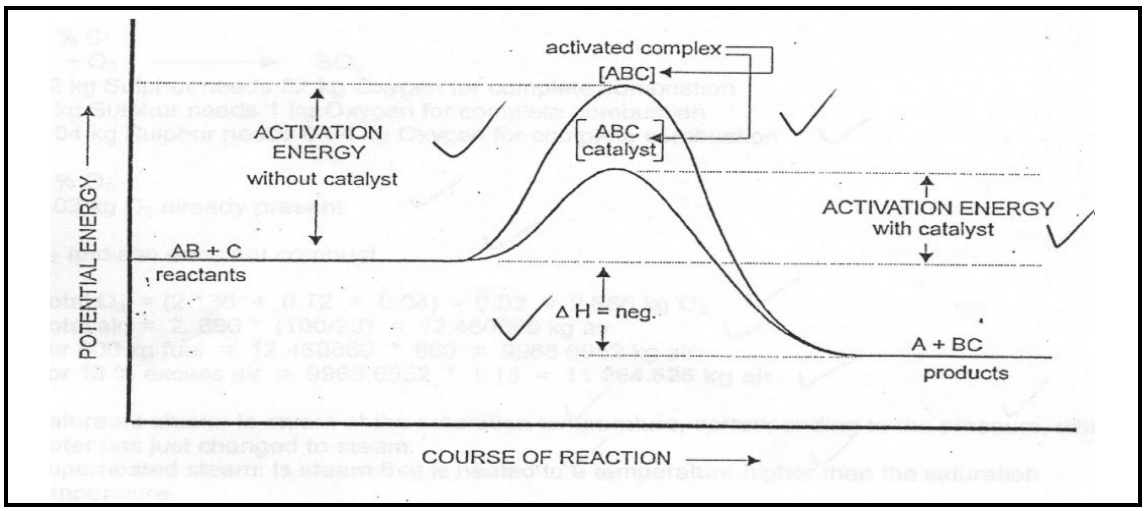


(4)

1.4
- Become soft and melt when heated
- Become hard again without losing their properties when they cool down again
- Acid resistance
- Reasonably dissolve in organic solvents like acetone and benzene

(Any relevant 4 × 1) (4)

1.5



The role of catalyst is to cause (produce) an activated complex at a lower temperature or energy level than would be caused without a catalyst.✓ In the case of heterogeneous catalysis the reactants are absorbed on the surface of the catalyst and this, requiring less energy to react, weakens the bonds of the reagents.✓ In other cases the catalyst causes intermediate reactions, which immediately cause dissociation of the reagents and then the final reaction(s) leaving the catalyst unchanged.✓ (Any relevant 7 × 1) (7)

[20]

QUESTION 2

2.1
- Granular
- Reflective
- Cell-type or cellular
- Fibrous (Any relevant 4 × 1) (4)

2.2
- Economical reasons
- Process control
- Safety (Any relevant 3 × 1) (3)

2.3
- Waterproofing
- Vibration
- Physical maltreatment (Any relevant 3 × 1) (3)

2.4 All the requirements for complete combustion must prevail.✓ The combustible elements such as carbon, hydrogen and sulphur combine with oxygen to form completely combusted products such as carbon dioxide, water vapour and sulphur dioxide.✓ (2)

2.5 2.5.1

$$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$$ ✓

0,2 + 70 m^3 H_2 requires = $14 \times \frac{1}{2}$
= 7 m^3 O_2✓

$$CO + \frac{1}{2}O_2 \rightarrow CO_2$$ ✓

0,35 × 70 CO requires = 24,5 × 0,5
= 12,25 m^3 O_2✓

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$ ✓

0,3 × 70 CH_4 requires = 21 × 2
= 42 m^3 O_2✓

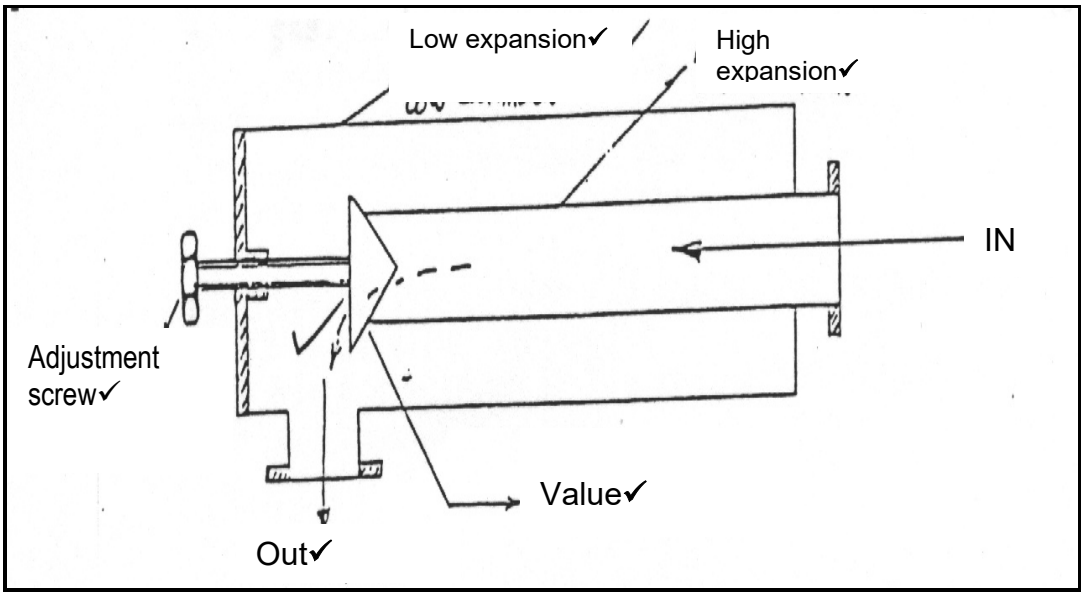
Total O_2 requirements = 7 +12,25 + 42 – (0,15 × 70)✓
= 61,25 – 10,5
= 50,75 m^3 O_2✓ (8)

2.5.2 Total air required at 3% excess air = $\frac{50,75 \times 103}{21}$ ✓
= 248 , 92m^3 air✓ (2)

[22]

QUESTION 3

3.1



(Any relevant 4 × 1) (4)

- When the steam trap is cold, the valve is open, draining air and condensate.
- When hot steam enters the trap, the tube expands and closes the opening.
- Due to that, steam flow ceases and the valve again cools down and opens.
- Condensate flows in again and the process repeats.

(Any relevant 4 × 1) (4)

3.2 3.2.1 After the flu-gas leaves the superheated tubes, it still contains energy.✓ This energy is utilised to heat feed water by means of the economiser. This is conducted to the feed water causing the water temperature to rise.✓

3.2.2 It increases the hot boiler feed-water energy. From the bottom of the steam drum,✓ with the aid of circulation it is pumped through the tubes above the combustion chamber of the steam boiler back to the steam drum.✓

3.2.3 Preheated flu-gas exiting the economiser to the stack still contains heat energy.✓ A preheater or recuperator is used to transfer this energy to the combustion air, which, simultaneously with the fuel, goes into the boiler.✓

(3 × 2) (6)

3.3
- Mechanical
- Thermostatic
- Thermodynamic

(3)
[17]

QUESTION 4

4.1
- Impure or dirty material
- High pressure medium or material
- Water
- Hot media
- Smaller volume
- Noncondensable gasses or vapours (6)

4.2
- Spray ponds
- Cooling towers
- Absorbers
- Steam strippers
- Fractionation columns (Any 3 × 1) (3)

4.3
- Air or gas build-up due to poor venting
- Incorrect inlet and outlet pipe diameter for the volume to be processed
- Use of wrong temperatures, pressures or flows not according to design specifications
- Excessive deposits in exchangers
- Excessive spacing between baffles and shell or baffles and tubes due to corrosion
- Tube leakage
- Poor drainage from the exchanger (Any relevant 6 × 1) (6)

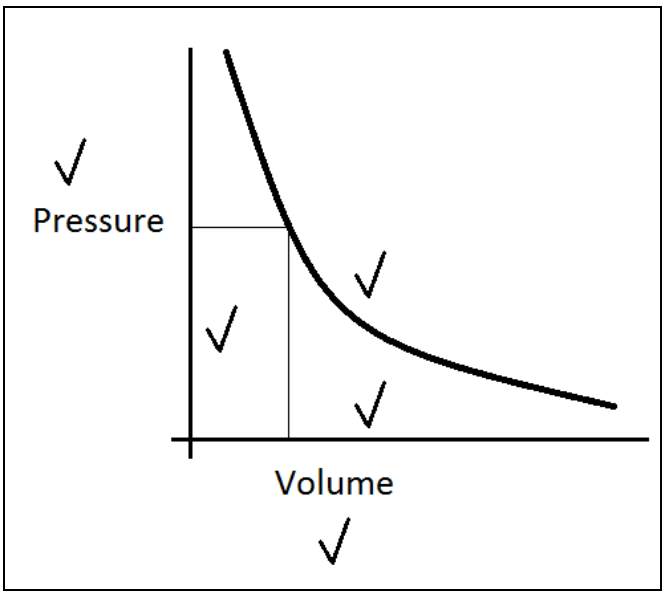
4.4 4.4.1 They improve the contact time between the heating medium and the heated medium.✓ In cross-flow baffles the tubes fit tighter in the baffles, but portions of the baffles are cut-away.✓ The baffles are placed in such a way that the cut away part alternates from the top to bottom so that the cross flow is achieved.✓
(Any relevant 3 × 1) (3)

4.4.2 Thermal resistance to heat transfer is made up of several individual resistances, for example condensate film, metal wall or heating surface, and scale liquor-side.✓ Heat transfer coefficient is the sum of the inverse of the resistances.✓ (Any relevant 2 × 1) (2)

[20]

QUESTION 5

5.1



(5)

5.2 When air is compressed, its volume is reduced✓ and its pressure is increased.✓ Also, due to the heat of compression, the temperature of the air will increase.✓ If the heat of compression, causing the increase in temperature could be removed as quickly as it is generated,✓ then the temperature of the air would remain constant and power required to drive the compressor would be substantially reduced.✓ (Any relevant 5 × 1) (5)

5.3 5.3.1 The vapour is withdrawn from the evaporator by absorbing it in a liquid.✓ The resulting solution, called the strong solution,✓ is then heated and the vapour is driven off at a higher pressure so that it may then be condensed.✓ This condensed vapour or liquid refrigerant is then passed through an expansion valve into the evaporator which is at a lower pressure,✓ where it absorbs heat and is vaporised once more.✓ (Any relevant 5 × 1) (5)

5.3.2 It is the ratio of the capacity to the displacement expressed in percent.✓ The capacity is always less than the displacement because of clearance between the piston and the cylinder heads,✓ leakage through valves and other losses.✓ (Any relevant 3 × 1) (3)

5.3.3 The compressor has two or more cylinders or different sizes.✓ The largest is the first stage or low-pressure cylinder✓ and the smallest one is the last stage or high-pressure cylinder.✓ (3)
(Any relevant 3 × 1) **[21]**

TOTAL: 100

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