higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

PLANT OPERATION THEORY N3

5 APRIL 2018

This marking guideline consists of 5 pages.

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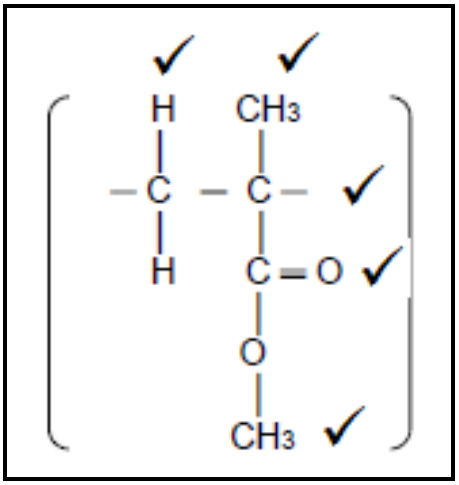
QUESTION 1: CHEMISTRY AND CHEMICAL PROCESSES

1.1 VULCANISED POLYBUTADIENE VS POLYETHYLENE
There is still at least one double bond available for vulcanisation.✓ Vulcanisation is the heating with sulphur to form sulphur bridges between two chains.✓ These crosslinks make the rubber harder.✓ Polyethylene has no available double bonds for vulcanisation.✓ (4)

1.2



POLYMETHYL METHACRYLATE (5)

1.3
- Transition metal catalyst
- Metal oxide
- Transition oxide
- Special synthetic catalyst (4)

1.4 It is the artificial manufacturing of products under suitable conditions of temperature and pressure✓ so that sufficient products under these conditions are formed to make the whole process economically viable.✓ (2)

EXAMPLE
Ammonia: N_2 (g) + H_2 (g) = NH_3 (g)

Sulphuric acid: SO_2 (g) + O_2 (g) = SO_3 (g)

Ethanol: C_2H_4 (g) + H_2O (l) = C_2H_5OH (l) (Any correct example) (2)

1.5 It is when the catalyst and the reactants are in the same phase✓ or state during the reaction e.g. all are liquid or all are solid or all are gaseous. ✓ (2)
[19]

QUESTION 2: COMBUSTION, FUELS AND THERMAL INSULATION

2.1 $C_6H_{12} + 9O_2 \rightarrow 6CO_2 + 6H_2O$✓
[(6 × 12) + (12 × 1)] kg C_6H_{12} requires (9 × 16 × 2) kg O_2 ✓✓
∴84 kg C_6H_{12} requires 288 kg O_2 for complete combustion ✓
1,8 kg C_6H_{12} requires 288 ÷ 84 × 1,8

= 6,17 kg O_2✓

Air required at 2% excess = 6,17 × 102 ÷ 23✓

= 27,4 kg air ✓ (7)

2.2 2.2.1 Water (H_2O) ✓✓ (2)

2.2.2 Carbon Monoxide (CO) or Carbon Dioxide (CO_2) ✓✓ (2)

2.2.3 Sulphur Dioxide (SO_2) ✓✓ (2)

2.3 • It is the ratio of the dry saturated steam contained in the wet steam and the total mass of the mixture (water plus steam) ✓✓ (2)
[15]

QUESTION 3: STEAM BOILERS AND STEAM TRAPS

3.1 Dry saturated steam requires less energy to absorb maximum heat,✓ whereas superheated steam requires much more energy to generate maximum heat.✓ It is therefore more expensive than dry saturated steam. Superheated steam requires thorough isolation as a small loss of heat can cause a great change in temperature✓ due to the smaller heat capacity (sensible heat).✓ (4)

3.2 STEAM TABLES

ts = 201,4 °C
h_f = 859 kJ/kg
h_{fg} = 1 933 kJ/kg

Energy to add = [((ts-101,4) ÷ ts) × hf] + [hfg × X]✓

= [((201,4 - 101,4) ÷ 201,4) x 859] + [1 933 × 0,9]✓✓

= 2 166,214 kJ/kg✓

= 2 166 214 kJ/ton✓

Energy to produce 18 ton/h steam

= [18 × 2 166 214] ÷ [0,9 × 1 000] MJ/h✓

= 43 324 ,28 ÷ 1 000 GJ/h✓

= 43,324 GJ/h✓

Fuel oil consumption = 43,324 ÷ 18,232✓

= 2,4 ton/h✓ (10)

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3.3
- Maximise equipment capacity
- Maximise heat transfer
- Less chance of corrosion
- Elimination of water hammer
- Dilution of steam
- Prevent steam losses (Any 5 × 1) (5)

[19]

QUESTION 4: HEAT TRANSFER AND HEAT EXCHANGERS

4.1
- Condensers:✓ Used for cooling of gases or vapor's to condense to the fluid phase.✓
- Reboiler:✓ In most cases steam is used as heating medium when the bottom product of the towers is to be heated.✓
- Coolers:✓ Hot fluids are normally cooled with water as cooling medium.✓
- Vaporisers:✓ Heat is added to convert a fluid to the gaseous phase.✓ (8)

4.2 It is a constant relating to a specific material,✓ e.g. mild steel has a specific rate at which it allows heat to flow through it✓ and so does scale, stagnant condensate layers, etc.✓ For heat transfer, the heat transfer coefficient must be as high as possible,✓ while for insulation the heat transfer coefficient must be as low as possible. Units for U = kJ/h/m2/°C✓ (5)

4.3
- Shell
- Connections
- Tubesheet
- Head
- Gaskets
- Mounting
- Baffles
- Tube bundle (Any relevant 8 × 1) (8)

[21]

QUESTION 5: COMPRESSION, COOLING, PUMPS AND INSTRUMENTATION

5.1
- It should not be poisonous.
- It should not be explosive or flammable.
- It should not be corrosive.
- It should boil at a low temperature at atmospheric pressure.
- It should require a large amount of latent heat of vaporisation to change it from a liquid to a gas after its boiling point has been reached.
- Its cost should not be excessive.
- It should have a low condensing pressure.
- It should have an inoffensive odour. (Any relevant 8 × 1) (8)

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5.2 Mechanical control systems: speed controller of a steam engine manipulates levers using centrifugal force and rotational speed✓✓
Hydraulic control systems: hydraulic operation of machines lift heavy loads or perform hard work ✓✓
Pneumatic control system: compressed air is used to operate a system or to provide a signal or impulse ✓✓
Electrical and electronic control systems: work is done by electrical apparatus and electrical signals or impulses even sound or light are transmitted and received for various purposes✓✓

(Any relevant 4 × 2) (8)

5.3 It states that the pressure of a contained volume of a gas is proportional to the temperature of the gas. ✓✓
$V_i/T_i = V_f/T_f$✓✓ (4)

5.4

5.4.1 FALSE

5.4.2 FALSE

5.4.3 TRUE

5.4.4 TRUE

5.4.5 FALSE

5.4.6 FALSE

(6×1) (6)
[26]

TOTAL: 100

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