<table>
<thead>
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<th><strong>PROGRAM</strong></th>
<th>NATIONAL DIPLOMA</th>
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<tr>
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<td>CHEMICAL ENGINEERING</td>
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<tr>
<td><strong>SUBJECT</strong></td>
<td>CHEMICAL ENGINEERING</td>
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<td>TECHNOLOGY IIIA</td>
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<tr>
<td><strong>DATE</strong></td>
<td>WINTER SSA EXAMINATION 2016</td>
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<td>26 JULY 2016</td>
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<tr>
<td><strong>DURATION</strong></td>
<td>(SESSION 1) 08:00 - 11:00</td>
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<td><strong>TOTAL MARKS</strong></td>
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<td><strong>FULL MARKS</strong></td>
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<td><strong>EXAMINER</strong></td>
<td>MRS T MASHIFANA</td>
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<tr>
<td><strong>MODERATOR</strong></td>
<td>DR H RUTTO</td>
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<tr>
<td><strong>NUMBER OF PAGES</strong></td>
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<tr>
<td><strong>INSTRUCTIONS</strong></td>
<td>NON-PROGRAMMABLE CALCULATORS</td>
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<tr>
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<td>PERMITTED (ONLY ONE PER CANDIDATE)</td>
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<td>ANSWER ALL THE QUESTIONS.</td>
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Ammonia is to be produced in a plant as shown in the diagram. The flow-rate of 
**nitrogen** into the plant is 40 mol min⁻¹. Stream F is joined by a large re-cycle stream R 
to form the feed F' to the reactor. 10% of the **reactants** entering the reactor are 
converted to ammonia. After the reactor, 99% of the ammonia is removed from the 
stream in a condenser as a pure liquid, and the rest together with un-reacted nitrogen 
and hydrogen is recycled to the reactor in Stream R as shown.

1.1. Write the reaction to produce ammonia. (3)

1.2. What is the flow-rate (mol min⁻¹) of hydrogen in the feed (F) if the ratio of 
hydrogen to nitrogen is 3:1? (4)

1.3. Explain why the hydrogen should be in the correct stoichiometric ratio to 
nitrogen. (2)

1.4. Calculate the flow-rates (mol min⁻¹) of ammonia produced in the plant in 
stream A. (4)

1.5. Perform an overall mass balance (in g min⁻¹) around the plant (Streams F and 
A) and comment on the result. AW: H: 1 gmol⁻¹; N: 14 gmol⁻¹. (7)

1.6. Calculate the flow-rate of the components in the recycle stream. (15)

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**QUESTION 2**

2.1. Derive the Bernoulli equation from first principles. (22)

2.2. In the diagram, a pump is situated above the suction 
point and pumps water from the bottom to the top tank 
(both open). The head loss due to friction on the suction 
side, \( \Delta h_f = 3 \text{ m} \), while that on the discharge side, \( \Delta h_d = 4 \text{ m} \). Take the viscosity and density of water to be 1 cP and 1000 kg m⁻³ respectively. The temperature of the 
water is 300K, which is equivalent to a vapour pressure of 35.31 kPa from the 
steam tables. Calculate the NPSH and comment fully on the result. (9)

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[35]

[31]

3/…
CHEMICAL ENGINEERING TECHNOLOGY IIIA

CMTA321

QUESTION 3

Air at 0.05kgs\(^{-1}\) is carried over a flat piece of land and isothermally at 25°C in a galvanized iron 200mm internal diameter pipe, and the pressure in the pipe drops from 1500Pa at the beginning to 500Pa at the end.

3.1. Is the flow compressible? (3)

3.2. Estimate the length of the pipe. (23)

3.3. How much heat per kg of air is required to maintain a constant temperature? (11)

3.4. Explain how this heat is transferred (the modes of heat transfer involved). (3)

Given: Air viscosity = 1.8x10\(^{-5}\)Pa.s

Air molecular mass = 29g.mol\(^{-1}\).

1ft=12inch.

1inch=2.54cm

QUESTION 4

A hot flat round plate is placed in a large room. The plate has a diameter 254mm and is 50.8mm thick. The surface of the plate is at 427°C and the temperature of the surroundings (walls, floor and ceiling) is 27°C. Cool air at 17°C is circulated around the plate to assist the cooling process.

4.1. If the heat loss is from the top, bottom and side of the plate, calculate the heat loss from the plate due to radiation. (8)

4.2. Calculate the heat loss due to convection. (3)

4.3. What percentage of the total heat loss is due to convection? (5)

Assume a heat transfer coefficient \(h = 25\text{Wm}^{-2}\text{K}^{-1}\).

\(\sigma = 5.67 \times 10^{-8}\text{Wm}^{-2}\text{K}^{-4}\).

TOTAL MARKS =122

FULL MARKS =122