higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

PROCESS TECHNOLOGY
NQF LEVEL 3

(6050353)

2 December 2024 (X-paper)
09:00–12:00

Calculators may be used.

This question paper consists of 6 pages and an addendum of 7 pages.

597Q1N2402

Copyright reserved

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)
PROCESS TECHNOLOGY
NQF LEVEL 3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use only a black or blue pen.
5. Write neatly and legibly.

Copyright reserved

SECTION A

QUESTION 1

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.5) in the ANSWER BOOK.

1.1 The most common and useful type of impeller is …

A radial flow.
B rushton.
C shaft.
D stator mixer.

1.2 The streams that flow in a circular motion around a tank.

A Turbulent
B Drag
C Surges
D Tangential flow streams

1.3 One of the disadvantages of a plate heat exchanger.

A Turbulence in the narrow flow channels cause a large pressure loss
B Not competitive where the PHE is suitable
C Large temperature fluctuations can cause recuperator components to expand and contract, possibly leading to cracks or separations
D Leakage of up to a few percent between fluid streams is not uncommon in ceramic recuperators

1.4 The reason for using L-footed tension wound is that …

A it provides the best protection against atmospheric corrosion.
B it prevents over-pressuring of the tube.
C airside corrosion is not high.
D it provides the tube with more protection against atmospheric corrosion.

1.5 BIOMASS is a fuel type which is … in colour.

A colourless to brown
B honey blonde to dark brown
C light yellow
D pale yellow, colourless to brown

(5 × 1) **[5]**

Copyright reserved

QUESTION 2

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (2.1–2.5) in the ANSWER BOOK.

2.1 Aeration is to expose water to oxygen.

2.2 A chemical reaction occurs when substances called reagents are not mixed together and react with each other to form something different to the starting materials.

2.3 One of the advantages of a double-tube heat exchanger is that it takes up space.

2.4 Cooling towers cool water by exposing it to air.

2.5 Pipeline transportation moves oil from one country to another.

(5 × 1) **[5]**

QUESTION 3

Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–J) next to the question number (3.1–13.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
3.1	It easily evaporates at normal temperatures	A	vane
		B	basin
3.2	A broad blade attached to a rotating axis or wheel that is moved by air or water	C	charcoal
3.3	A black porous material that consists of 85–95% carbon and is used as fuel	D	peat
		E	sparger
3.4	A scale that shows how high or low acidity or alkalinity in a solution is – 0 is very acidic and 14 is very alkaline	F	pH
		G	nozzle
3.5	It is a component which sprays or sprinkles gas into a liquid	H	volatility
		I	slag
		J	plume

(5 × 1) **[5]**

TOTAL SECTION A: 15

Copyright reserved

SECTION B

QUESTION 4

4.1 Study the ADDENDUM 1 (attached) and answer the questions below:

4.1.1 What is the name of the MSDS? (1)

4.1.2 Calculate the molar mass of this MSDS. (2)

4.1.3 Name THREE ways how this substance may enter to human beings. (3)

4.1.4 Explain SIX procedures to be followed to clear up a spill of the substance in ADDENDUM 1 (attached). (6)

4.2 Shear forces are forces that break particles up or help two dissimilar liquids to integrate.

Draw diagrams to indicate the THREE states of the effect of shear forces with regard to mixing. (3)

[15]

QUESTION 5

5.1 Define the following terms:

5.1.1 Chemical fouling

5.1.2 Precipitation fouling

(2 × 2) (4)

5.2 What is an air-cooled heat exchanger also called? (1)

5.3 Describe the SIX main benefits of using ACHEs. (6)

5.4 State SIX advantages of a natural gas. (6)

5.5 Explain the THREE ways of transferring heat in heating devices. (3)

5.6 Differentiate between *fire-tube* and *water-tube boilers*. (4)

5.7 Describe the function of the following components in direct-fired heaters:

5.7.1 Burner

5.7.2 Steam drum

5.7.3 Economiser

(3 × 2) (6)

Copyright reserved

5.8 The purpose of instrumentation is to measure and control process variables.

Name FIVE instruments that are used in testing the combustion efficiency in most fired heaters. (5)
[35]



QUESTION 6

6.1 Describe the purpose of *coagulation*. (2)

6.2 List THREE things that coagulation can be used for. (3)

6.3 Draw and label a flow diagram of the general water purification process. (10)

6.4 Define the following terms:

6.4.1 Membranes

6.4.2 Permeability

(2 × 2) (4)

6.5 List TWO classes of membranes. (2)

6.6 Name TWO modes of membranes. (2)

6.7 State EIGHT uses of ultrafiltration (UF). (8)

6.8 Name FOUR different types of foulants. (4)
[35]



TOTAL SECTION B: 85
GRAND TOTAL: 100

Copyright reserved

ADDENDUM

Material Safety Data Sheet

Section 1 – Chemical Product and Company Identification

MSDS Name: Sulfuric acid 90-98%
Catalog Numbers: AC124640000, AC124640010, AC124640011, AC124640025, AC124640026, AC124645000, AC124645001, AC133610000, AC133610011, AC133610025, AC133610026, AC133610051, AC302070000, AC302070010, AC302070011, AC302070025, AC302070026, AC388270000, AC424520000, AC424520026, AC424525001, 13361-0010, 42452-0025, 42452-5000, A298-212, A298N119, A300-212, A300-225LB, A300-500, A300-500LC, A300-612GAL, A300-700LB, A300C-212, A300C-212002, A300C-212003, A300C-212LC, A300C212004, A300C212005, A300C212006, A300C212007, A300C212008, A300C212009, A300C212010, A300J-500, A300P-500, A300S-212, A300S-212LC, A300S-500, A300SI-212, A468-1, A468-2, A468-250, A468-500, A484-212, A510-212, A510-500, A510SK-212, NC9008405, NC9825433, S71211SC, S71211SCMF, S79200, SA174-212, SA174-4, SA176-4, SA196-500
Synonyms: Hydrogen sulfate; Oil of vitriol; Vitriol brown oil; Mattling acid; Battery acid; Sulphuric acid; Electrolyte acid; Dihydrogen sulfate; Spirit of sulfur; Chamber acid.
Company Identification:

Fisher Scientific
1 Reagent Lane
Fair Lawn, NJ 07410

For information, call: 201-796-7100
Emergency Number: 201-796-7100
For CHEMTREC assistance, call: 800-424-9300
For International CHEMTREC assistance, call: 703-527-3887

Section 2 – Composition, Information on Ingredients

CAS#	Chemical Name	Percent	EINECS/ELINCS
7664-93-9	Sulfuric acid	90-98	231-639-5

Section 3 – Hazards Identification

EMERGENCY OVERVIEW

Appearance: clear colorless to yellow liquid.
Danger! Causes eye and skin burns. Causes digestive and respiratory tract burns. May be fatal if mist inhaled. Strong inorganic acid mists containing sulfuric acid may cause cancer. Concentrated sulfuric acid reacts violently with water and many other substances under certain conditions. May cause lung damage. Hygroscopic (absorbs moisture from the air). Corrosive to metal.
Target Organs: Lungs, teeth, eyes, skin.

Copyright reserved Please turn over

Potential Health Effects
Eye: Causes severe eye burns. May cause irreversible eye injury. May cause blindness. May cause permanent corneal opacification. The severity of injury depends on the concentration of the solution and the duration of exposure.
Skin: Causes skin burns. The severity of injury depends on the concentration of the solution and the duration of exposure.
Ingestion: May cause severe and permanent damage to the digestive tract. Causes gastrointestinal tract burns.
Inhalation: May cause irritation of the respiratory tract with burning pain in the nose and throat, coughing, wheezing, shortness of breath and pulmonary edema. Causes chemical burns to the respiratory tract. Inhalation may be fatal as a result of spasm, inflammation, edema of the larynx and bronchi, chemical pneumonitis and pulmonary edema. Because its vapor pressure is negligible, it exists in the air only as a mist or spray. Exposure may impair lung function and cause mucostasis (reduced mucous clearance).
Chronic: Prolonged or repeated skin contact may cause dermatitis. Prolonged or repeated inhalation may cause nosebleeds, nasal congestion, erosion of the teeth, perforation of the nasal septum, chest pain and bronchitis. Prolonged or repeated eye contact may cause conjunctivitis. Effects may be delayed. Workers chronically exposed to sulfuric acid mists may show various lesions of the skin, tracheobronchitis, stomatitis, conjunctivitis, or gastritis. Occupational exposure to strong inorganic acid mists containing sulfuric acid is carcinogenic to humans.

Section 4 – First Aid Measures

Eyes: In case of contact, immediately flush eyes with plenty of water for a t least 15 minutes. Get medical aid immediately.
Skin: In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid immediately. Wash clothing before reuse.
Ingestion: If swallowed, do NOT induce vomiting. Get medical aid immediately. If victim is fully conscious, give a cupful of water. Never give anything by mouth to an unconscious person.
Inhalation: POISON material. If inhaled, get medical aid immediately. Remove victim to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
Notes to Physician: Monitor arterial blood gases, chest x-ray, and pulmonary function tests if respiratory tract irritation or respiratory depression is evident. Treat dermal irritation or burns with standard topical therapy. Effects may be delayed. Do NOT use sodium bicarbonate in an attempt to neutralize the acid.

Section 5 – Fire Fighting Measures

General Information: As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Use water spray to keep fire-exposed containers cool. Substance is noncombustible. Contact with water can cause violent liberation of heat and splattering of the material. Contact with metals may evolve flammable hydrogen gas. Runoff from fire control or dilution water may cause pollution. Approach fire from upwind to avoid hazardous vapors and toxic decomposition products. Strong dehydrating agent, which may cause ignition of finely divided materials on contact. Oxides of sulfur may be produced in fire.

Copyright reserved

Extinguishing Media: Use extinguishing media most appropriate for the surrounding fire. Do NOT get water inside containers. If water is used, care should be taken, since it can generate heat and cause spattering if applied directly to sulfuric acid.
Flash Point: Not applicable.
Autoignition Temperature: Not available.
Explosion Limits, Lower: Not available.
Upper: Not available.
NFPA Rating: (estimated) Health: 3; Flammability: 0; Instability: 2; Special Hazard: -W-

Section 6 – Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks: Avoid runoff into storm sewers and ditches which lead to waterways. Clean up spills immediately, observing precautions in the Protective Equipment section. Carefully scoop up and place into appropriate disposal container. Provide ventilation. Do not get water inside containers. Cover with dry earth, dry sand, or other non-combustible material followed with plastic sheet to minimize spreading and contact with water.

Section 7 – Handling and Storage

Handling: Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Do not allow water to get into the container because of violent reaction. Do not get in eyes, on skin, or on clothing. Keep container tightly closed. Discard contaminated shoes. Use only with adequate ventilation. Do not breathe spray or mist. Do not use with metal spatula or other metal items. Inform laundry personnel of contaminant's hazards.
Storage: Do not store near combustible materials. Keep container closed when not in use. Store in a cool, dry, well-ventilated area away from incompatible substances. Do not store near alkaline substances. Store protected from moisture. Ideally, sulfuric acid should be stored in isolation from all other chemicals in an approved acid or corrosives safety cabinet.

Section 8 – Exposure Controls, Personal Protection

Engineering Controls: Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits. Use a corrosion-resistant ventilation system.
Exposure Limits

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Sulfuric acid	0.2 mg/m3 TWA (thoracic fraction)	1 mg/m3 TWA 15 mg/m3 IDLH	1 mg/m3 TWA

Copyright reserved Please turn over

OSHA Vacated PELs: Sulfuric acid: 1 mg/m3 TWA
Personal Protective Equipment
Eyes: Wear chemical splash goggles and face shield.
Skin: Wear neoprene gloves, apron, and/or clothing. Viton gloves are recommended.
Clothing: Wear appropriate protective clothing to prevent skin exposure.
Respirators: Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Section 9 – Physical and Chemical Properties

Physical State: Liquid
Appearance: oily - clear colorless to yellow
Odor: odorless
pH: 0.3 (1N solution)
Vapor Pressure: < 0.001 mm Hg @ 20 deg C
Vapor Density: 3.38 (air=1)
Evaporation Rate: Slower than ether.
Viscosity: 21 mPas @ 25 C
Boiling Point: 290 - 338 deg C
Freezing/Melting Point:10 deg C
Decomposition Temperature:340 deg C
Solubility: Soluble with much heat
Specific Gravity/Density:1.84
Molecular Formula:H2SO4
Molecular Weight:98.07

Section 10 – Stability and Reactivity

Chemical Stability: Sulfuric acid reacts vigorously, violently or explosively with many organic and inorganic chemicals and with water.
Conditions to Avoid: Excess heat, exposure to moist air or water, Note: Use great caution in mixing with water due to heat evolution that causes explosive spattering. Always add the acid to water, never the reverse..
Incompatibilities with Other Materials: Metals, oxidizing agents, reducing agents, bases, acrylonitrile, chlorates, finely powdered metals, nitrates, perchlorates, permanganates, epichlorohydrin, aniline, carbides, fulminates, picrates, organic materials, flammable liquids.
Hazardous Decomposition Products: Oxides of sulfur.
Hazardous Polymerization: Has not been reported.

Copyright reserved

Section 11 – Toxicological Information

RTECS#:
CAS# 7664-93-9: WS5600000
LD50/LC50:
CAS# 7664-93-9:
Draize test, rabbit, eye: 250 ug Severe;
Inhalation, mouse: LC50 = 320 mg/m3/2H;
Inhalation, mouse: LC50 = 320 mg/m3;
Inhalation, rat: LC50 = 510 mg/m3/2H;
Inhalation, rat: LC50 = 510 mg/m3;
Oral, rat: LD50 = 2140 mg/kg;

Carcinogenicity:
CAS# 7664-93-9:

- **ACGIH:** A2 - Suspected Human Carcinogen (contained in strong inorganic acid mists)
- **California:** carcinogen, initial date 3/14/03 (listed as Strong inorganic acid mists containing sulfuric acid).
- **NTP:** Known carcinogen (listed as Strong inorganic acid mists containing s).
- **IARC:** Group 1 carcinogen

Epidemiology: Workers exposed to industrial sulfuric acid mist showed a statistical increase in laryngeal cancer. This suggests a possible relationship between carcinogenesis and inhalation of sulfuric acid mist.
Teratogenicity: Sulfuric acid was not teratogenic in mice and rabbits, but was slightly embryotoxic in rabbits (a minor, rare skeletal variation). The animals were exposed to 5 and 20 mg/m3 for 7 hr/day throughout pregnancy. Slight maternal toxicity was present at the highest dose in both species.
Reproductive Effects: No information found
Mutagenicity: There are no mutagenicity studies specifically of sulfuric acid. However, there are established effects of reduced pH in mutagenicity testing, as would be caused by sulfuric acid. These effects are an artifact of low pH and are not necessarily due to biological effects of sulfuric acid itself.
Neurotoxicity: No information found
Other Studies:

Section 12 – Ecological Information

Ecotoxicity: Fish: Bluegill/Sunfish: 49 mg/L; 48Hr; TLm (tap water @ 20C)
Fish: Bluegill/Sunfish: 24.5 ppm; 48Hr; TLm (fresh water)

Section 13 – Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.
RCRA P-Series: None listed.
RCRA U-Series: None listed.

Copyright reserved Please turn over

Section 14 – Transport Information

	US DOT	Canada TDG
Shipping Name:	SULFURIC ACID	SULFURIC ACID
Hazard Class:	8	8
UN Number:	UN1830	UN1830
Packing Group:	II	II

Section 15 – Regulatory Information

US FEDERAL

TSCA
CAS# 7664-93-9 is listed on the TSCA inventory.
Health & Safety Reporting List
None of the chemicals are on the Health & Safety Reporting List.
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.
CERCLA Hazardous Substances and corresponding RQs
CAS# 7664-93-9: 1000 lb final RQ; 454 kg final RQ
SARA Section 302 Extremely Hazardous Substances
CAS# 7664-93-9: 1000 lb TPQ
SARA Codes
CAS # 7664-93-9: immediate, delayed, reactive.
Section 313
This material contains Sulfuric acid (CAS# 7664-93-9, 90-98%),which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.
Clean Air Act:
This material does not contain any hazardous air pollutants.
This material does not contain any Class 1 Ozone depletors.
This material does not contain any Class 2 Ozone depletors.
Clean Water Act:
CAS# 7664-93-9 is listed as a Hazardous Substance under the CWA.
None of the chemicals in this product are listed as Priority Pollutants under the CWA.
None of the chemicals in this product are listed as Toxic Pollutants under the CWA.
OSHA:
None of the chemicals in this product are considered highly hazardous by OSHA.
STATE
CAS# 7664-93-9 can be found on the following state right to know lists: California, New Jersey, Pennsylvania, Minnesota, Massachusetts.

Copyright reserved Please turn over

California Prop 65
The following statement(s) is(are) made in order to comply with the California Safe Drinking Water Act:
WARNING: This product contains Sulfuric acid, listed as `Strong inorganic acid mists contain', a chemical known to the state of California to cause cancer.
California No Significant Risk Level: None of the chemicals in this product are listed.

European/International Regulations

European Labeling in Accordance with EC Directives
Hazard Symbols:
C
Risk Phrases:
R 35 Causes severe burns.

Safety Phrases:
S 26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 30 Never add water to this product.
S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

WGK (Water Danger/Protection)
CAS# 7664-93-9: 2
Canada - DSL/NDSL
CAS# 7664-93-9 is listed on Canada's DSL List.
Canada - WHMIS
This product has a WHMIS classification of D2A, D1A, E.
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by those regulations.
Canadian Ingredient Disclosure List
CAS# 7664-93-9 is listed on the Canadian Ingredient Disclosure List.

Section 16 – Additional Information

MSDS Creation Date: 4/22/1999
Revision #15 Date: 2/13/2008

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.

Copyright reserved