UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 24, 2019

Dr. Steven Reese, Director
Oregon State University
100 Radiation Center
Corvallis, Oregon 97331-5903

SUBJECT: EXAMINATION REPORT NO. 50-243/OL-19-01, OREGON STATE UNIVERSITY

Dear Dr. Reese:

During the week of June 10, 2019, the U.S. Nuclear Regulatory Commission (NRC) administered operator licensing examinations at your Oregon State University Radiation Center reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the *Code of Federal Regulations,* Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Ms. Michele DeSouza at (301) 415-0747 or via internet e-mail Michele.DeSouza@nrc.gov.

Sincerely,

Anthony J. Mendiola, Chief
Research and Test Reactors Oversight Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-243

Enclosures:
1. Examination Report No. 50-243/OL-19-01
2. Written Examination

cc: w/o enclosures: See next page

Oregon State University

Docket No. 50-243

cc:

Mayor of the City of Corvallis
Corvallis, OR 97331

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Mr. Daniel Harlan, Chairman
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Test, Research and Training
Reactor Newsletter
Attention: Amber Johnson
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4418 Stadium Drive
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U.S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-243/OL-19-01

FACILITY DOCKET NO.: 50-243

FACILITY LICENSE NO.: R-106

FACILITY: TRIGA

EXAMINATION DATES: June 10-14, 2019

SUBMITTED BY: Michele DeSouza 06/14/2019
Michele DeSouza, Chief Examiner Date

SUMMARY:
During the week of June 10, 2019, the NRC administered operator licensing examinations to five Reactor Operators (ROs). The five RO candidates passed all applicable portions of the examination(s).

REPORT DETAILS

1. Examiner: Michele DeSouza, Chief Examiner, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	5/0	N/A	5/0
Operating Tests	5/0	N/A	5/0
Overall	5/0	N/A	5/0

3. Exit Meeting:
Michele C. DeSouza, Chief Examiner, NRC
Robert Schickler, Reactor Administrator, Oregon State University Radiation Center Reactor
Celia Oney, Reactor Supervisor, Oregon State University Radiation Center Reactor

Facility comments were accepted prior to the administration of the written examination. Upon completion of the examination, the NRC Examiner met with facility staff representatives to discuss the results. A facility training weakness was identified, in that the majority of the candidates did not have a thorough understanding of the measuring channels. The NRC examiner recommended further emphasis and training to ensure proficiency. The NRC examiner also noted that OSTROP 3.R addresses when primary coolant is required during operations however, due to the newly installed heat exchanger that alters these requirements, OSTROP 3.R should be updated as soon as possible. At the conclusion of the meeting, the NRC examiner thanked the facility for their support in the administration of the examination.

U. S. NUCLEAR REGULATORY COMMISSION
NON-POWER REACTOR LICENSE EXAMINATION

FACILITY: Oregon State University

REACTOR TYPE: TRIGA

DATE ADMINISTERED: 06/10/2019

CANDIDATE: _____

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the Answer sheet provided. Attach all Answer sheets to the examination. Point values are indicated in parentheses for each question. A 70% in each category is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

CATEGORY VALUE	% OF TOTAL	CANDIDATE'S SCORE	% OF CATEGORY VALUE	CATEGORY
20.00	33.3	_____	_____	A. REACTOR THEORY, THERMODYNAMICS AND FACILITY OPERATING CHARACTERISTICS
20.00	33.3	_____	_____	B. NORMAL AND EMERGENCY OPERATING PROCEDURES AND RADIOLOGICAL CONTROLS
20.00	33.3	_____	_____	C. FACILITY AND RADIATION MONITORING SYSTEMS
60.00		_____ FINAL GRADE	_____ %	TOTALS

All work done on this examination is my own. I have neither given nor received aid.

_____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil only to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each Answer sheet.

6. Mark your Answers on the Answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and Answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your Answer is on your Answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

13. When you have completed and turned in your examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

EQUATION SHEET

$$\dot{Q} = \dot{m} c_P \Delta T = \dot{m} \Delta H = UA\Delta T$$

$$P_{\max} = \frac{(\beta - \rho)^2}{(2\alpha \ell)}$$

$$\lambda_{eff} = 0.1 \sec^{-1}$$

$$P = P_0 \, e^{t/\mathrm{T}}$$

$$SCR = \frac{S}{-\rho} \cong \frac{S}{1 - K_{eff}}$$

$$\ell^* = 1 \times 10^{-4} \text{ sec}$$

$$SUR = 26.06 \left[\frac{\lambda_{eff} \rho + \dot{\rho}}{\overline{\beta} - \rho} \right]$$

$$CR_1 (1 - K_{eff_1}) = CR_2 (1 - K_{eff_2})$$

$$CR_1 (-\rho_1) = CR_2 (-\rho_2)$$

$$P = \frac{\beta(1 - \rho)}{\beta - \rho} P_0$$

$$M = \frac{1}{1 - K_{eff}} = \frac{CR_2}{CR_1}$$

$$P = P_0 \, 10^{SUR(t)}$$

$$M = \frac{1 - K_{eff_1}}{1 - K_{eff\,2}}$$

$$SDM = \frac{1 - K_{eff}}{K_{eff}}$$

$$\mathrm{T} = \frac{\ell^*}{\rho - \overline{\beta}}$$

$$\mathrm{T} = \frac{\ell^*}{\rho} + \left[\frac{\overline{\beta} - \rho}{\lambda_{eff} \rho + \dot{\rho}} \right]$$

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

$$\Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{K_{eff_1} K_{eff_2}}$$

$$\rho = \frac{K_{eff} - 1}{K_{eff}}$$

$$DR = DR_0 \, e^{-\lambda t}$$

$$DR_1 \, d_1^{\,2} = DR_2 d_2^{\,2}$$

$$DR = \frac{6 Ci \, E(n)}{R^2}$$

$$\frac{(\rho_2 - \beta)^2}{Peak_2} = \frac{(\rho_1 - \beta)^2}{Peak_1}$$

DR – Rem, Ci – curies, E – Mev, R – feet

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1 Curie = 3.7 x 10^{10} dis/sec

1 Horsepower = 2.54 x 10^3 BTU/hr

1 BTU = 778 ft-lb

1 gal (H_2O) ≈ 8 lb

c_P = 1.0 BTU/hr/lb/°F

1 kg = 2.21 lb

1 Mw = 3.41 x 10^6 BTU/hr

°F = 9/5 °C + 32

°C = 5/9 (°F - 32)

c_p = 1 cal/sec/gm/°C

Category A – Reactor Theory, Thermodynamics, & Facility Operating Characteristics

ANSWER SHEET

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

A01 a b c d ___

A02 a b c d ___

A03 a b c d ___

A04 a b c d ___

A05 a ___ b ___ c ___ d ___ (0.25 each)

A06 a b c d ___

A07 a b c d ___

A08 a b c d ___

A09 a b c d ___

A10 a b c d ___

A11 a b c d ___

A12 a b c d ___

A13 a b c d ___

A14 a b c d ___

A15 a b c d ___

A16 a b c d ___

A17 a b c d ___

A18 a b c d ___

A19 a b c d ___

A20 a b c d ___

(***** END OF CATEGORY A *****)

Category B – Normal/Emergency Operating Procedures and Radiological Controls

ANSWER SHEET

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

B01 a b c d ___

B02 a b c d ___

B03 a b c d ___

B04 a b c d ___

B05 a b c d ___

B06 a _____ b _____ c _____ d _____ (0.25 each)

B07 a b c d ___

B08 a b c d ___

B09 a b c d ___

B10 a b c d ___

B11 a b c d ___

B12 a b c d ___

B13 a b c d ___

B14 a b c d ___

B15 a b c d ___

B16 a b c d ___

B17 a b c d ___

B18 a b c d ___

B19 a b c d ___

B20 a b c d ___

(***** END OF CATEGORY B *****)

Category C – Facility and Radiation Monitoring Systems

ANSWER SHEET

Multiple Choice (Circle or X your choice)
If you change your Answer, write your selection in the blank.

C01 a ___ b ___ c ___ d ___ (0.25 each)

C02 a b c d ___

C03 a b c d ___

C04 a b c d ___

C05 a b c d ___

C06 a b c d ___

C07 a ___ b ___ c ___ (0.33 each)

C08 a b c d ___

C09 a b c d ___

C10 a b c d ___

C11 a b c d ___

C12 a b c d ___

C13 a b c d ___

C14 a b c d ___

C15 a b c d ___

C16 a b c d ___

C17 a b c d ___

C18 a b c d ___

C19 a b c d ___

C20 a b c d ___

(***** END OF CATEGORY C *****)
(********** END OF EXAMINATION **********)

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.01 [1.0 point]
How is the term k_{eff} defined?

a. production / (absorption + leakage)

b. (absorption + leakage) / production

c. absorption / (production + leakage)

d. (production + leakage) / absorption

Question A.02 [1.0 point]
Which ONE of the following is the stable reactor period which will result in a power rise from 10% to 100% power in 10 seconds?

a. 4 seconds

b. 8 seconds

c. 11 seconds

d. 15 seconds

Question A.03 [1.0 point]
The reactor is critical at 100 watts, a control rod is moved that results in a positive reactivity insertion of 0.126% $\Delta k/k$. Which ONE of the following will be the stable reactor period as a result of this reactivity insertion? Given $B_{eff} = 0.0078$

a. 21 seconds

b. 34 seconds

c. 45 seconds

d. 52 seconds

Question A.04 [1.0 point]
Which ONE of the reactions below describes a method of production and removal of Xenon?

a. ${}_{52}Te^{134} \rightarrow \gamma + {}_{53}I^{134} \rightarrow p + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

b. ${}_{52}Te^{135} \rightarrow \gamma + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow {}_{0}n^{1} + {}_{54}Xe^{136} \rightarrow \beta^- + {}_{56}Ba^{135}$

c. ${}_{52}Te^{134} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \gamma + {}_{55}Cs^{135} \rightarrow \beta^+ + {}_{56}Ba^{135}$

d. ${}_{52}Te^{135} \rightarrow \beta^- + {}_{53}I^{135} \rightarrow \beta^- + {}_{54}Xe^{135} \rightarrow \beta^- + {}_{55}Cs^{135} \rightarrow \beta^- + {}_{56}Ba^{135}$

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.05 [1.0 point, 0.25 points each]
Match the term listed in Column A with its corresponding unit listed in Column B. (Answers used once).

Column A	Column B
a. 1 barn	1. cm^{-1}
b. Neutron Flux	2. $10^{-24}cm^2$
c. Reaction Rate	3. Neutrons/cm^2-sec
d. Macroscopic Cross Section	4. Fissions/cm3-sec

Question A.06 [1.0 point]
Which ONE of the following is the principal source of heat in the reactor after a shutdown from an extended 100 kW operation?

a. Spontaneous fission of Uranium - 238

b. Production of delayed neutrons

c. Subcritical reaction of photo neutrons

d. Decay of fission fragments

Question A.07 [1.0 point]
A subcritical reactor, k_{eff} is increased from 0.861 to 0.941. Which ONE of the following is the amount of reactivity that was added to the core?

a. 0.07 $\Delta k/k$

b. 0.085 $\Delta k/k$

c. 0.099 $\Delta k/k$

d. 0.121 $\Delta k/k$

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.08 [1.0 point]
Which ONE of the following is the mechanism by which a nucleus can gain stability by converting a neutron to a proton or vice versa?

a. Alpha Decay

b. Beta Decay

c. Gamma Decay

d. Photoelectric Effect

Question A.09 [1.0 point]
Which ONE of the following types of neutrons has a mean generation lifetime of about 12 seconds?

a. Fast

b. Prompt

c. Thermal

d. Delayed

Question A.10 [1.0 point]
What is the amount of reactivity added if the multiplication factor, k, is increased from 0.800 to 0.950?

a. 0.083 $\Delta k/k$

b. 0.197 $\Delta k/k$

c. 0.211 $\Delta k/k$

d. 0.364 $\Delta k/k$

Question A.11 [1.0 point]
Which type of neutron interaction (light nuclei) is most important in moderating fast neutrons to thermal energies?

a. Radiative capture

b. Elastic scattering

c. Inelastic scattering

d. Charged particle reaction

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.12 [1.0 point]
Reactor power is stable at 0.1 watt. Reactor Operator inserts a sample with a worth of 0.06% Δk/k into the reactor core. Which ONE of the following best describes the reactor kinetics? The reactor is:

a. Critical

b. Subcritical

c. Supercritical

d. Prompt Critical

Question A.13 [1.0 point]
Given a source strength of 200 neutrons per second (N/sec) and a multiplication factor of 0.6, which ONE of the following is the expected stable neutron count rate? CR = S/(1-k)

a. 250 N/sec

b. 350 N/sec

c. 500 N/sec

d. 600 N/sec

Question A.14 [1.0 point]
Which ONE of the following conditions describes a critical reactor?

a. $k_{eff} = 1$; $\Delta k/k(\rho) = 1$

b. $k_{eff} = 1$; $\Delta k/k(\rho) = 0$

c. $k_{eff} = 0$; $\Delta k/k(\rho) = 1$

d. $k_{eff} = 0$; $\Delta k/k(\rho) = 0$

Question A.15 [1.0 point]
Which ONE of the following is the number of neutrons in the tritium nucleus ($_1T^3$ or $_1H^3$)?

a. 1

b. 2

c. 3

d. 4

Category A: Theory, Thermodynamics & Facility Operating Characteristics

Question A.16 [1.0 point]
What is the meaning that any point on a differential rod worth curve represents?

a. The negative reactivity added as the rod is inserted.

b. The cumulative area under the differential curve starting from the bottom of the core.

c. The amount of reactivity that a given unit of rod motion would insert at that position in the core.

d. The zero reactivity when the rod is on the bottom and the positive reactivity being added as the rod is withdrawn.

Question A.17 [1.0 point]
Which of the following is an example of a FERTILE material?

a. Th-232

b. U-233

c. U-235

d. Pu-239

Question A.18 [1.0 point]
Which ONE of the following defines the term EFFECTIVE MULTIPLICATION FACTOR?

a. Change in the number of neutrons per second that causes a fission event.

b. Number of neutrons by which neutron population changes per generation.

c. Rate of change of reactor power in neutron per second.

d. Fractional change in neutron population per generation.

Question A.19 [1.0 point]
Which ONE of the following changes does not require a movement of control rods in order to maintain constant reactor power?

a. Nitrogen-16 formation

b. Xenon-135 buildup

c. Uranium-235 burnup

d. Pool water temperature decreases

Question A.20 [1.0 point]

Which ONE of the following most accurately describes the reason that fission products such as Xenon-135 and Samarium-149 have the most substantial impact in reactor design and operation?

a. Xenon-135 and Samarium-149 cause excess positive reactivity in the core.

b. Xenon-135 and Samarium-149 burn up causes an increase in the thermal flux.

c. Xenon-135 and Samarium-149 have large absorption cross sections resulting in a large removal of neutrons from the reactor.

d. Xenon-135 and Samarium-149 produce fast fission neutrons, resulting in the net increase in the fast neutron population of the reactor core.

(*****END OF CATEGORY A*****)

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.01 [1.0 point]
Which ONE of the following changes requires NRC approval prior to being implemented?

a. Deletion of an administrative control requirement listed in the Oregon State Technical Specification

b. Deletion of a check listed in OSTROP-2, Startup Checklist

c. Change to the individual appointed to the Oregon State Level-2 position

d. Replace the primary cooling pump with an identical pump

Question B.02 [1.0 point]
Which ONE of the following is an example of a record to be retained for the lifetime of the reactor facility?

a. Reactor log book

b. Drawings of the reactor facility

c. Experiments performed with the reactor

d. Records of meeting and audit reports of the Reactor Safety Committee

Question B.03 [1.0 point]
Which ONE of the following is a Channel Check per Oregon State Technical Specification?

a. Adjustment of the wide range linear channel in accordance with recent data collected during a reactor power calibration

b. During performance of the daily checklist, you press the scram button to verify a scram on the safety system channel

c. During performance of the daily checklist, you compare the prestart readings of the radiation area monitors to the previous day readings

d. You expose a 2 mCi check source to the stack particulate monitor detector to verify that it alarms at 10,000 cpm

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.04 [1.0 point]
The dose rate from a mixed beta-gamma point source is 100 mrem/hr at one foot and is 0.1 mrem/hr at ten feet. What percentage of the source consists of beta radiation?

a. 25%

b. 45%

c. 70%

d. 90%

Question B.05 [1.0 point]
Which ONE of the following radioactive GASES might be an indication of a fuel element leak?

a. Cs^{137}

b. Xe^{135}

c. Ar^{41}

d. N^{16}

Question B.06 [1.0 point, 0.25 each]
List the appropriate reference: 10CFR19, 10CFR20, 10CFR50, 10CFR55 corresponding to the below statements.

a. Individual radiation exposure data

b. Postings of notices to workers

c. Medical examination every two years by a physician

d. Technical information including the proposed maximum power level

Question B.07 [1.0 point]
Oregon State University Emergency Plan defines the *Emergency Planning Zone* as which ONE of the following?

a. within the walls of the reactor bay

b. within the walls of the Reactor Building

c. within the walls of the Radiation Center

d. within a 100-meter radius of the center of the reactor core

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.08 [1.0 point]
Which ONE of the following scram is associated with a Beam Port 3 abnormal operations?

a. Safety scram

b. External scram

c. High Voltage scram

d. Experiment scram

Question B.09 [1.0 point]
Which ONE of the following is classified as a Class I Emergency event?

a. Site Area Emergency

b. Alert

c. Notification of Unusual Events

d. Personnel and Operational Events

Question B.10 [1.0 point]
What is the MINIMUM level of management who shall be present at the facility during a recovery from an unplanned or unscheduled shutdown?

a. Duty Senior Reactor Operator

b. Reactor Administrator

c. Reactor Operator

d. Radiation Center Director

Question B.11 [1.0 point]
Which ONE of the following is the definition for "Deep Dose Equivalent"?

a. The portion of the dose equivalent received from radiation sources outside the body.

b. The concentration of a radionuclide in air which, if inhaled by an adult worker for a year, results in a total effective dose equivalent of 100 mrem.

c. The dose equivalent at a tissue depth of 1cm.

d. The portion of the dose equivalent received from radiative material taken into the body.

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.12 [1.0 point]
Which ONE of the following terms matches the emergency response definition, "measures taken in anticipation of an uncontrolled release of radioactive material, or after an uncontrolled release of radioactive material has occurred, for the purpose of preventing or minimizing personnel radiation doses or dose commitments"?

a. Mitigating Action

b. Preventive Action

c. Protective Action

d. Deterrent Action

Question B.13 [1.0 point]
An area in which radiation levels could result in an individual receiving a dose equivalent of 120 mrem/hr at 30 cm is defined as:

a. Radiation Area

b. High Radiation Area

c. Very High Radiation Area

d. Unrestricted Area

Question B.14 [1.0 point]
What is the maximum worth of ALL experiments in accordance with OSU Technical Specification?

a. $2.30

b. $2.00

c. $1.00

d. $0.50

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.15 [1.0 point]
Which ONE of the following will violate 10 CFR 55.53, 'conditions of licenses', if you are currently a licensed operator?

a. Requalification written examination was 12 months ago

b. Last license renewal was 48 months ago

c. Previous quarter you were the licensed operator for 8 hours

d. Requalification operating test was 14 months ago

Question B.16 [1.0 point]
How long will it take a 2-Curie source to decay to 0.02 Curie? Half-life = 2 years

a. 3 years

b. 9 years

c. 13 years

d. 17 years

Question B.17 [1.0 point]
According to OSU Emergency Plan, which ONE of the following would be classified as an Alert?

a. An explosion, or a fire in the Radiation Center Complex lasting more than 10 minutes.

b. A major personnel injury such as a severe cut, wound, or burn.

c. A person experiencing a heart attack, stroke, or other severe physical ailment of rapid onset.

d. Loss of greater than 80% of the reactor tank water.

Question B.18 [1.0 point]
Which ONE of following types of radiation has the LOWEST Quality Factor specified in 10 CFR 20?

a. Gamma/X-ray/Beta

b. Thermal Neutrons

c. Fast Neutrons/Protons

d. Alpha Particles

Category B: Normal/Emergency Procedures and Radiological Controls

Question B.19 [1.0 point]
Which ONE of the following is NOT required to be audited on an annual basis by the Reactor Operations Committee?

a. Emergency Plan

b. Technical Specification

c. Physical Security Plan

d. Reactor Operator Requalification Plan

Question B.20 [1.0 point]
What is the BASIS, according to OSU Technical Specifications, that the OSU water temperature cannot exceed 49°C?

a. Effective cooling of the fuel

b. To minimize the degradation of the aluminum tank

c. To maintain the usefulness of the demineralizer resin

d. Maximin operation of the skimmer and proper shielding

(*****END OF CATEGORY B*****)

Category C: Facility and Radiation Monitoring Systems

Question C.01 [1.0 point, 0.25 each]
Match the control Rod indication lights (UP, DOWN, CONT/ON) in Column A with the possible Control Rod conditions in Column B. (each used only once).

Column A	Column B
a. ON, OFF, ON	1. Rod drive completely withdrawn, magnets making contact
b. OFF, ON, ON	2. Rod and drive between limits, magnets making contact
c. OFF, OFF, ON	3. Rod and drive at lower limits, magnets making contact
d. OFF, OFF, OFF	4. After scram, Control Rod down

Question C.02 [1.0 point]
Which ONE of the following monitors is required by OSU Technical Specifications to cause an immediate shut down from a ventilation high activity alarm?

a. Continuous Air

b. Reactor Top Radiation

c. Exhaust Particulate Radiation

d. Exhaust Gas

Question C.03 [1.0 point]
Which ONE of the following is the Argon-41 discharge concentration limits to unrestricted areas?

a. 3E-6 μCi/ml

b. 4E-6 μci/ml^3

c. 4E-6 μCi/ml

d. 2E-6 μCi/ml^3

Question C.04 [1.0 point]
Pulsing the reactor in steady state mode is prevented by which ONE of the following interlocks?

a. 1 kW pulse

b. Transient Rod Cylinder

c. Shim, Safety, and Reg. rod drive circuit

d. Wide-Range Log power level channel

Category C: Facility and Radiation Monitoring Systems

Question C.05 [1.0 point]
Which ONE of the following radionuclides presence in the secondary system would indicate a possible fuel leak from the primary system?

a. Nitrogen-16

b. Argon-41

c. Calcium-40

d. Cesium-135

Question C.06 [1.0 point]
Samples are transferred in and out of the pneumatic transfer system using which gas?

a. Air

b. Carbon Dioxide

c. Water

d. Nitrogen

Question C.07 [1.0 point, 0.33 each]
For irradiations involving quantities of Uranium and Thorium, match the Irradiation Facility in Column A with the associated limit in Column B?

Column A	Column B
a. Rotating Rack	1. 30 MWh
b. Thermal Column	2. 0.083 MWh
c. Pneumatic Transfer	3. 1 MWh

Question C.08 [1.0 point]
Which ONE of the following is a possible reason for high radiation downstream of the demineralizer?

a. Fuel element failure

b. High flow rate through the demineralizer

c. High pressure upstream of the demineralizer

d. High temperature in the demineralizer

Category C: Facility and Radiation Monitoring Systems

Question C.09 [1.0 point]
Which ONE of the following is NOT normally checked on the CAM during a routine start-up check list?

a. Oil level

b. Flow rate

c. Filter paper

d. Background reading

Question C.10 [1.0 point]
What indication shows whether the reactor tank water is within acceptable parameters to prevent reactor tank corrosion?

a. Demineralizer Flow Rate

b. Primary Water Conductivity

c. Primary Water Activity

d. Demineralizer Area Radiation Monitor #12

Question C.11 [1.0 point]
Which channel is grounded in Square Wave and Pulse Mode?

a. Safety

b. Linear

c. Period

d. Log-N

Question C.12 [1.0 point]
Which ONE of the following is an indication of a fuel element failure?

a. High pressure upstream of demineralizer

b. High flow rate through demineralizer

c. High radiation downstream the demineralizer

d. High radiation at the demineralizer

Category C: Facility and Radiation Monitoring Systems

Question C.13 [1.0 point]
Which ONE of the following scram indications is required in all effective modes?

a. Power level

b. Fuel element temperature

c. Preset timer

d. High voltage

Question C.14 [1.0 point]
Which ONE of the following is a reason fuel element temperature must be limited in the TRIGA fuel element, to prevent a fuel element cladding failure?

a. Fission product build up

b. Excessive pressure from Ar-41 expansion

c. Excessive pressure from air, fission product gases, and zirconium hydride hydrogen dissociation

d. Distortion of the fuel element due to a phase change of the 304-stainless steel

Question C.15 [1.0 point]
Which ONE of the following is a reason OSU utilizes Environmental TLDs?

a. Provides a reference dose for comparison

b. Ensures personnel doses are less than allowable limits

c. Monitors areas for Argon-41 release

d. Maintains areas using byproduct materials

Question C.16 [1.0 point]
Which ONE of the following is the method used to minimize mechanical shock to the standard control rods on a scram?

a. A small spring located at the bottom of the rod

b. A piston drives air out of a dashpot as the rod nears the bottom of travel

c. A piston drives water out of a dashpot as the rod nears the bottom of its travel

d. An electrical-mechanical brake energizes when the rod down limit switch is energized

Category C: Facility and Radiation Monitoring Systems

Question C.17 [1.0 point]
Which ONE of the following is a reason for a neutron startup source in the core?

a. Ensure the reactor change from subcritical to critical by using a neutron source

b. Provides a reference point where all instruments undergo a check before the reactor is brought to a critical position

c. Provides enough neutrons to assure proper nuclear instrumentation response during initial reactor startup

d. Prevent the reactor changing from a manual to automatic if a period exceeds 10 seconds

Question C.18 [1.0 point]
Which ONE of the following is an indication of a clogged demineralizer?

a. High flow rate through the demineralizer

b. High pressure upstream of demineralizer

c. High radiation downstream of demineralizer

d. High radiation at the demineralizer

Question C.19 [1.0 point]
Which ONE of the following correctly describes the characteristic of the unirradiated 30/20 fuel rods used at the OSTR?

a. The uranium content is a nominal 30 weight%, enriched to less than 20% U-235, and the natural erbium content is homogenously distributed with a nominal 1.1 weight%

b. The hydrogen to zirconium atom ratio (in the ZrHx) shall be between 1.5 to 1.8

c. The uranium content is a nominal 30 weight%, enriched to less than 20% U-235, and no erbium content

d. The uranium content is 30 weight%, enriched to less than 20% U-235, and the natural erbium content is homogenously distributed with a nominal 0.90 weight%

Category C: Facility and Radiation Monitoring Systems

Question C.20 [1.0 point]
Which ONE of the following systems provide power to the transient rod?

a. Pneumatic

b. Rack and Pinion

c. Centrifugal gears

d. Bearing and ball

(*****END OF CATEGORY C*****)
((*****END OF EXAMINATION*****))

Category A: Theory, Thermodynamics & Facility Operating Characteristics

A.01
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations*

A.02
Answer: a
Reference: $P=P_o e^{t/T} \rightarrow t=T*\ln(P/P_o)$ T = 10/Ln(100/10), T = 4.34 seconds

A.03
Answer: d
Reference: 0.126%Δk/k = 0.00126Δk/k; $T = (\beta - \rho) / \lambda_{eff} \rho$; (0.0078 – 0.00126) / (0.1)(0.00126) = 51.9 seconds

A.04
Answer: d
Reference: DOE Fundamentals Handbook, NRPT, Vol. 2, Module 3, EO 4.1, p.35, KAPL, "Chart of the Nuclides", 17th Ed.

A.05
Answer: a. 2; b. 3; c. 4; d. 1
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 2.6

A.06
Answer: d
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 1, EO 4.9, p.61

A.07
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.4, Page 3-20&21
$\Delta\rho=(k_{eff2}-k_{eff1})/(k_{eff1}*k_{eff2})$ = (0.941-0.861)/(0.861*0.941) = 0.099 Δk/k

A.08
Answer: b
Reference: NRC Standard question

A.09
Answer: d
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, NP-02, Page 31

A.10
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*, Section 3.3.3, Page 3-21
$(keff_1-keff_2)/(keff_1*keff_2)$. (0.95 - 0.8)/(0.95*0.8) = 0.197 Δk/k

A.11
Answer: b
Reference: LaMarsh, 3rd edition, Section 3.6, Page 68-71

Category A: Theory, Thermodynamics & Facility Operating Characteristics

A.12
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 4.2

A.13
Answer: c
Reference: CR=S/(1-k)→150/(1-0.7) = 500 N/sec

A.14
Answer: b
Reference: Burn, *Introduction to Nuclear Reactor Operations*

A.15
Answer: b
Reference: Nuclides and Isotopes; N = A – Z; 3 – 1 = 2

A.16
Answer: c
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Example 7.2b, Page 7-4

A.17
Answer: a
Reference: DOE Fundamentals Handbook, NPRT, Vol. 1, Module 1, EO 4.3, p.52

A.18
Answer: d
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Section 1.3.1, Page 1-5

A.19
Answer: a
Reference: Burn, *Introduction to Nuclear Reactor Operations,* Problem 7.7.4, Page 7-17

A.20
Answer: c
Reference: DOE Fundamentals Handbook, NPRT, Vol. 2, Module 3, Page 34

Category B: Normal/Emergency Procedures and Radiological Controls

B.01
Answer: a
Reference: 10CFR50.59

B.02
Answer: b
Reference: OSU TS 6.9

B.03
Answer: c
Reference: OSU TS Definitions: 1.3, 1.4, 1.5

B.04
Answer: d
Reference: $(DR_1)(d_1)^2 = (DR_2)(d_2)^2$; 10CFR20, no Beta radiation at ten ft;
Calculate gamma at one ft: $(0.1)(10)^2 = (DR_2)(1)^2 = 10$ mrem/hr
100 mrem/hr – 10 mrem/hr = 90 mrem/hr or 90%

B.05
Answer: b
Reference: OSU TS 5.6

B.06
Answer: a. 10CFR20, b. 10CFR19, c. 10CFR55, d. 10CFR50
Reference: 10CFR19.11, 10CFR20.1501(2)(i), 10CFR50.34(1)(ii)(A), 10CFR55.21.

B.07
Answer: b
Reference: OSU Emergency Response Plan 6.0

B.08
Answer: b
Reference: OSTROP 1, A-7 SAR 7.4.1, pg. 11

B.09
Answer: c
Reference: OSU Emergency Response Plan 4.0, pg. 4-2

B.10
Answer: a
Reference: OSU Technical Specification 6.1.3.c.4

B.11
Answer: c
Reference: 10CFR20.1003, Definitions

B.12
Answer: c
Reference: OSU ERP 2.2

Category B: Normal/Emergency Procedures and Radiological Controls

B.13
Answer: b
Reference: 10CFR20

B.14
Answer: a
Reference: OSU Technical Specification 3.8

B.15
Answer: d
Reference: 10CFR55.53(i), 10CFR55.53(h), 10CFR55.53(e), 10CFR55.53(h), 10CFR55.59(c) and 10CFR55.59(c)(1)

B.16
Answer: c
Reference: $A=A_o*e^{-\lambda t}$; 0.02Ci = 2Ci* $e^{-\lambda t}$; λ = 0.963/2years = 0.3465; ln(0.02/2) = -0.3465*(t); -4.60/-0.3465 = t = 13.2 years

B.17
Answer: d
Reference: OSU Emergency Plan 4.0

B.18
Answer: a
Reference: 10 CFR 20.1004 OSU TRIGA Reactor Operator Training I & II, Radiological Protection OSU TRIGA Reactor Training Manual, Volume 4, pg. 8

B.19
Answer: b
Reference: OSTROP 6

B.20
Answer: b
Reference: OSTROP 7, I.D., pg. 5 TS 3.3.b and 3.3 Basis, pg. 16

Category C: Facility and Radiation Monitoring Systems

C.01
Answer: a. 1, b. 3, c. 2, d. 4
Reference: OSU TRIGA Reactor Operator Training II, Instrumentation & Control System
OSU TRIGA Reactor Training Manual, Volume 2, Table 2.1, pg. 12

C.02
Answer: c
Reference: OSU TS L6 Training Slides

C.03
Answer: c
Reference: OSU TS L6 Training Slides

C.04
Answer: b
Reference: OSU TS 3.2.3

C.05
Answer: d
Reference: Chart of the Nuclides, Fission products

C.06
Answer: a
Reference: OSU Training Manual Volume 1

C.07
Answer: a. 3, b. 1, c. 2
Reference: Approved Experiment B.11

C.08
Answer: d
Reference: NRC standard question

C.09
Answer: a
Reference: OSTROP 2

C.10
Answer: b
Reference: OSU TS 3.3, OSTROP 2

C.11
Answer: c
Reference: OSU Training Manual Volume 2

C.12
Answer: d
Reference: NRC standard question

Category C: Facility and Radiation Monitoring Systems

C.13
Answer: d
Reference: OSU TS 3.2.3, Table 2

C.14
Answer: c
Reference: OSU Technical Specification 3.2

C.15
Answer: a
Reference: NRC Standard question

C.16
Answer: c
Reference: OSU Training Manual Volume 1

C.17
Answer: c
Reference: NRC previous exam

C.18
Answer: b
Reference: Standard NRC question

C.19
Answer: a
Reference: OSU Technical Specification 5.3.3

C.20
Answer: a
Reference: OSU SAR 3.5.1 & 4.2.2 and Training Manual Volume 1

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