U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.:	50-223/OL-96-02
FACILITY DOCKET NO.:	50-223
FACILITY LICENSE NO.:	R-125
FACILITY:	University of Massachusetts – Lowell
EXAMINATION DATES:	September 23 – 25, 1996
EXAMINER:	Paul Doyle, Chief Examiner
SUBMITTED BY:	Paul Doyle, Chief Examiner 10/7/96 Date

SUMMARY:

During the week of September 23, 1996, the NRC administered Operator Licensing Examinations to three Reactor Operator candidates. Two candidates failed section B of the written examination only. One candidate passed all portions of the examination.

REPORT DETAILS

1. Examiner: Paul Doyle, Chief Examiner

2. Results:

	RO (Pass/Fail)	SRO (Pass/Fail)	Total (Pass/Fail)
NRC Grading:	1/2	0/0	1/2

3. Exit Meeting:

Participants:
Paul Doyle, Chief Examiner, NRC
Lee Bettenhausen, Reactor Supervisor, Univ. of Mass. - Lowell
Gunter Kegel, Facility Director, Univ. of Mass. - Lowell

Mr. Doyle thanked the facility for their assistance in administration of the examinations, and noted that all three candidates were strong on system knowledge.

SEPTEMBER 1996 EXAMINATION QUESTION COMMENTS

Question A.4:
Which ONE of the following elements has the SMALLEST microscopic cross section for absorption of neutrons?

a. H^1

b. H^2

c. C^{12}

d. U^{238}

Facility Comment: NRC answer is (b.), H^2, with reference to Table 2.3 of Introduction to Nuclear Reactor 0perations. That answer does *not* appear in the referenced table; D_20 is the entry which would have been a correct answer. The correct answer using the cited reference would be (c.), C^{12}. Further, the stem of the question does not specify the energy of the neutrons. If one were to consider, say, 2OMev, the cross-section for absorption for U^{238} is 0.0005 barn from BNL-325.
Proposed Resolution: Discard question. Stem is not definitive and answers are not those found in the cited reference.
NRC Resolution: Question deleted from this examination.

Question A.12:
Given: Primary Flow rate through heat exchanger = 1400 GPM; Secondary Flow rate through heat exchanger = 1200 GPM; $\Delta T_{Primary}$ = 13°F and Secondary INLET temperature is 73°F. Which one of the following should be the secondary OUTLET temperature?

a. ≈ 58°F

b. ≈ 62°F

c. ≈ 84°F

d. ≈ 88°F

Facility Comment: The answer key is incorrect; (d.) is the correct answer.
NRC Resolution: Answer key changed to reflect d as correct answer.

ENCLOSURE 2

Question A.17:
Explain how each of the following condidtions will change reactivity in the core (Increase, Decrease or No Change).

a. Place hollow steel cylinder (filled with air) next to core.

b. Increase Rod Speed.

c. Insert rabbit containing natural uranium into core.

d. Insert rabbit containing water into core.

Facility Comment: This question asks about changes in core reactivity for four situations. Answer (a.) "Place a hollow steel cylinder (filled with air) next to the core." The answer does not specify size of cylinder nor location of placement. Selection of the, size and the placement can result in increase, no change, or decrease of reactivity, so all answers are correct. Answer (c.) "Insert a rabbit containing natural uranium into the core." At UMLRR, the rabbits terminate alongside the core in the water reflector. The position of the carrier can be varied through the thermal flux peak with dramatic changes in neutron flux and energy spectrum. Again a choice of sample size and rabbit positioning can result in any of the three choices for reactivity change. Answer (d.) "Insert rabbit containing water into core." As with (c.) above, any of the choices are possible.
Suggested resolution: Discard Question A.17
NRC Resolution: Question deleted from this examination.

Question B.3
Match the general area radiation levels listed in column A with the corresponding type of radiation area listed in column B. (Note: Only one answer for each item in column A. Items from column B may be used more than once or not at all.)

	Column A		Column B
A.	15 mRem/hr	1.	Unrestricted Area
B.	65 mRem/hr	2.	Radiation Area
C.	203 mRem/hr	3.	High Radiation Area
D.	520 mRem/hr	4.	Very High Radiation Area

Facility Comment: The correct answer for matching item D., 520 mRem/hr, should be 3., High Radiation Area. See 10CFR20.1003.
NRC Resolution: Answer key changed to reflect 3 as correct for D.

Question B.7
You volunteered to help cleanup an accident at a local Power Reactor facility. During the cleanup you received 4.0 REM. What are your limits with respect to receipt of radiation at U. Mass-Lowell, based on this?

A. No effect on any radiation limits at U. Mass-Lowell. The radiation received during cleanup is tracked only by the power facility and does not count against **ANY** radiation dose which may be received at U. Mass-Lowell.

B. No effect on any radiation limits at U. Mass-Lowell. The radiation dose received during the cleanup is tracked as a Planned Special Exposure, at the facility, and is not applicable to U. Mass-Lowell doses.

C. Decrease in annual and life-time Planned Special Exposure (PSE) limits at U. Mass-Lowell. The radiation dose received during the cleanup is tracked as part of your Planned Special Exposure (PSE) limit.

D. Decrease of annual whole body limit at U. Mass-Lowell by 4 Rem.

Facility Comment: The stem of the question does not specify the date upon which the cleanup dose was obtained. If before January 1, 1994, the dose would not have been added if considered an emergency dose, making no answer correct; if not treated as an emergency dose, it would have been added to the occupational total, making (a.) the correct answer. If the cleanup dose occurred after January 1. 1994 and was obtained under a Planned Special Exposure, (c.) would be, correct.
Proposed Resolution: Accept (a.) or (c.) as correct.
NRC Resolution: Answer key modified to show either a or c as correct

Question B.11
Who by title(s) authorizes reentry after an evacuation of the containment due to high radiation? (NOTE: I am looking for who is responsible for authorizing reentry, NOT setting reentry requirements.)

A. The Emergency Director on his own.

B. The Radiation Protection Officer on his own.

C. The Emergency Director after consultation with the Radiation Protection Office.

D. The Radiation Protection Officer after consultation with the Operations Office.

Facility Comment: The citation for the answer, Emergency Plan para. 3-4, states: "The Emergency Director shall authorize reentry into the reactor building or portions thereof previously evacuated during the course of an emergency. It shall be the responsibility of the health physics personnel to establish reentry requirements, provide personnel monitoring, and insure that protective clothing and proper breathing equipment is utilized." Answer (a.) states ' "The Emergency Director on his own Answer (c.) states "The Emergency Director after consultation with the Radiation Protection Office". A Note on the stem states, "I am looking for who is responsible for authorizing reentry NOT setting reentry requirements". While answer (c.) is prudent and implied in para 3-4, (a.) is the correct answer to the question posed.
Proposed Resolution: Accept either (a.) or (c.) as correct
NRC Resolution: Answer key modified to show either a or c as correct

Question B.14:
Which ONE of the following conditions is an *Abnormal Occurrence* per the Technical Specification definition?

A. Primary Flow trip setpoint at 1400 gpm.

B. A secured experiment worth 0.25% ΔK/K.

C. A mercury thermometer is brought into containment.

D. Operation in Natural Circulation Mode with a pool level of 24 ft. above the top of the core.

Facility Comment: While it is true that instruments using mercury are prohibited in the reactor containment and bringing one into containment would constitute an observed inadequacy in administrative controls and thus an "Abnormal Occurrence" in terms of Technical Specfactions, Surveillance Procedure 12 uses a thermometer to calibrate temperature monitoring devices. The thermometer used is a mercury thermometer calibration traceable to NIST in accordance with 10CFR50, Appendix B, Criterion XII and specifically permitted by an exception to Standing Order #I. A better instrument to make the point of the question would be a mercury manometer.
Proposed Resolution: Discard this question since the purported answer is a permitted situation which occurs at least semiannually.
NRC Resolution: Question discarded for this examination.

Question C.5
The delay tank is designed to allow two short-lived isotopes to decay off. Which one of the following identifies the two short-lived isotopes?

A. N^{16}, O^{19}

B. N^{16}, Ar^{41}

C. Ar^{41}, O^{19}

D. O^{19}, H^{3}

Facility Comment: The answer key should be corrected to show (a.) as the correct answer.
NRC Resolution: Answer key changed to reflect a as correct answer.

Question C.14
A small earthquake causes an unisolable leak at the edge of the thermal column, and a loss of normal power. You move the core to the stall end and install the gate. City water is still available. How do you refill the stall pool?

A. Gravity drain from the day tank.

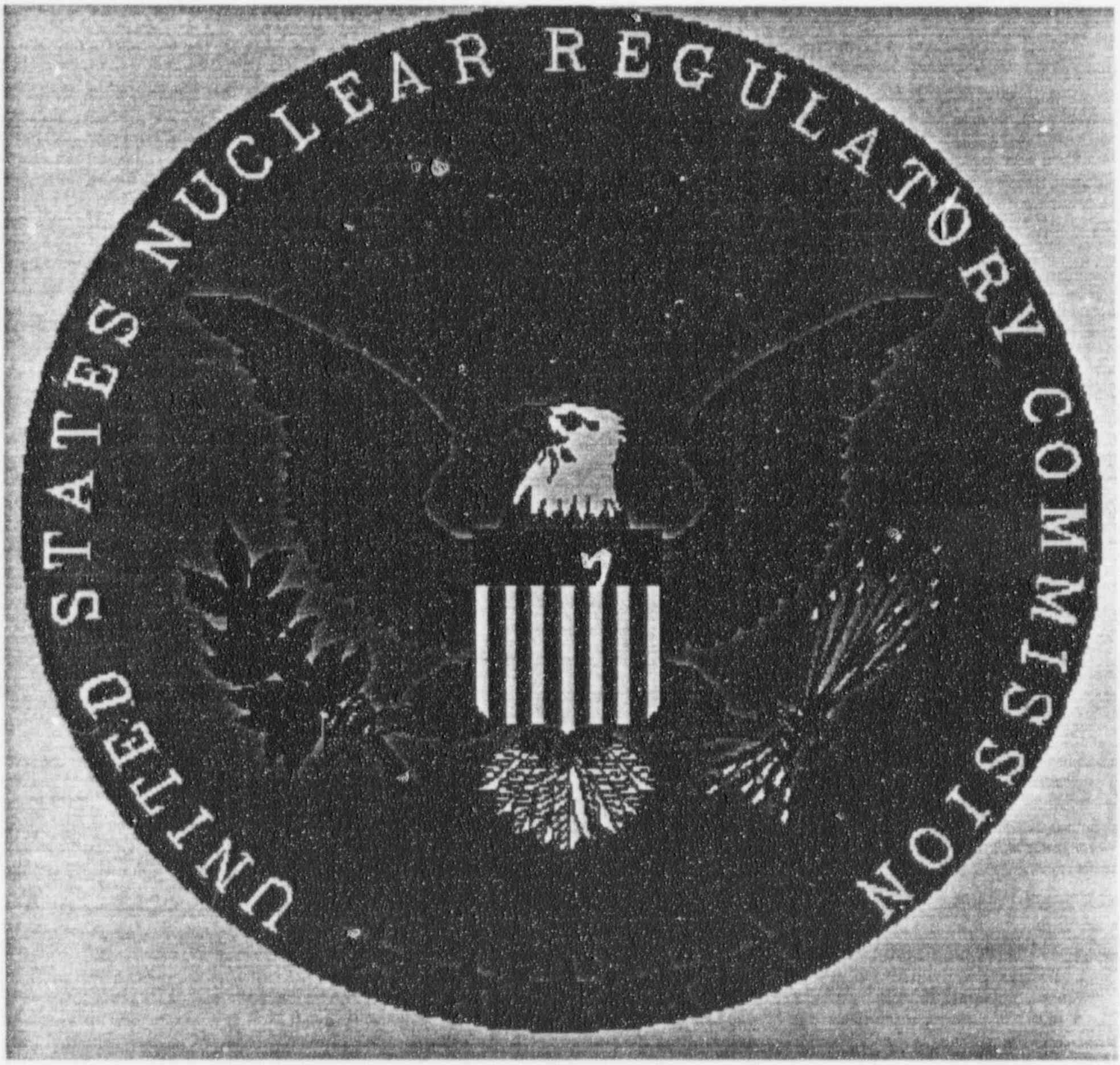
b. Using city water pressure, use normal makeup lineup.

C. You can't, the makeup pump has no power.

D. Gravity drain from the retention tank.

Facility Comment
This question confuses several ideas. Since the thermal column is at the end of the, stall pool, it is necessary to move the core to the bulk pool to install the pool gate and prevent further loss of shielding water. The question then asks how do you refill the stall pool, but does not indicate that the leak has been stopped. The safety emphasis should be on keeping the bulk pool with the radioactive core, and cobalt-60 sources well covered with water. Nevertheless, with city water available there are three ways to refill the pool: *1. bypass* the normal makeup lineup, including the pump, by opening M-17 and inject city water through the balance, of the makeup system into the pool; normal city water pressure is 60 psig and a head of 20 psig suffices; put a hose from a pool level sink into the pool; and, 3, bring the fire hosr, frorn the first floor, secure the nozzle so that it is directed into the pool and charge the fire hose.
Proposed resolution. Accept (b.) as correct since only one valve need be opened, as well as (c.)
NRC Resolution: Answer key modified to accept either b or c as correct answer

United States Nuclear Regulatory Commission
Operator Licensing Examination



University of Massachusetts — Lowell
09/23/96

ENCLOSURE 3

QUESTION A.1 [1.0]
Which one of the following factors would be MOST affected by an increase in poison loading in the reactor core?

a. ϵ, fast fission factor

b. f, thermal utilization factor

c. η, reproduction factor

d. p, resonance escape factor

QUESTION A.2 [1.0]
Given, α_T = 0.05% ΔK/K/°F, and the average rod worth of the regulating rod is 0.1% ΔK/K/inch, calculate the distance and direction of rod travel if the coolant were to decrease by 9°F.

a. ≈ ½ inch

b. ≈ 1 inch

c. ≈ 5 inches

d. ≈ 10 inches

QUESTION A.3 [1.0]
Which one of the following elements will cause a colliding fast neutron to lose the most energy?

a. H^1

b. H^2

c. C^{12}

d. U^{238}

QUESTION A.4 [1.0]
Which ONE of the following elements has the SMALLEST microscopic cross section for absorption of neutrons?

a. H^1

b. H^2

c. C^{12}

d. U^{238}

QUESTION A.5 [1.0]
You are adding fuel (the shaded boxes from right to left with respect to the core as depicted in figure 1. What type of 1/m plot would you anticipate (figure 2 or 3) and why?

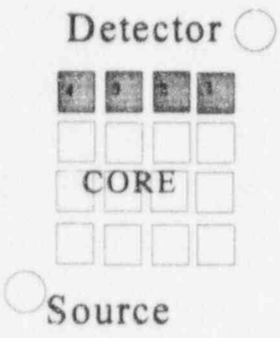


Figure 1

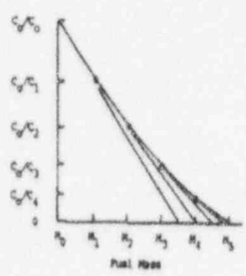


Figure 2

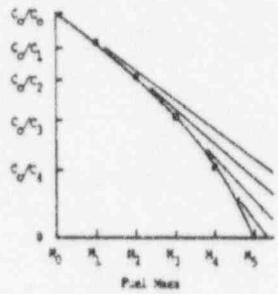


Figure 3

a. Figure 2, too close to source

b. Figure 3, too far from source

c. Figure 2, too close to detector

d. Figure 3, too far from detector

QUESTION A.6 [1.0]
Which ONE of the following is the cause of the indicated power to stabilize several hours following a reactor scram. (Assume source inserted in core, source range instrument on and reading 3 counts/second and no reactivity changes, i.e. no temperature changes, no fuel movement, no experiments added, etc.)

a. Continuing decay of the shortest lived delayed neutron precursor.

b. Gamma saturation of the source range detector.

c. Subcritical multiplication of source neutrons.

d. Neutron activation of the Source Range Detector.

QUESTION A.7 [1.0]
Which ONE of the following describes the MAJOR contributors to production and depletion of Xenon in an STEADY-STATE OPERATING reactor?

a. Production : Radioactive Decay of Iodine Depletion: Radioactive Decay

b. Production : Radioactive decay of Iodine Depletion: Neutron absorption

c. Production : Directly from fission Depletion: Radioactive Decay

d. Production : Directly from fission Depletion: Neutron absorption

QUESTION A.8 [1.0]
Which ONE of the following is the difference between prompt and delayed neutrons? Prompt neutrons ...

a. account for less than one percent of the neutron population, while delayed neutrons account for the rest.

b. are released during fast-fission events, while delayed neutrons are released during the thermal fission events.

c. Are released during the fission process (fast & thermal), while delayed neutrons are released during the decay process.

d. are the dominating factor in determining reactor period, while delayed neutrons have little effect on reactor period.

QUESTION A.9 [1.0]
K_{eff} for the reactor is 0.85. If you place an experiment of +17.6% ΔK/K worth of reactivity to the reactor what is the new K_{eff}?

a. 0.995

b. 0.9995

c. 1.005

d. 1.05

QUESTION A.10 [1.0]
All four control rods are worth 11.4% ΔK/K. Core excess is 4.2% ΔK/K. Regulating rod worth is 0.6% ΔK/K. If the regulating rod is stuck in the fully out position, calculate the actual (NOT TECHNICAL SPECIFICATION) Shutdown Margin. (Ignore temperature and poisons.)

a. 2.5% ΔK/K

b. 3.3% ΔK/K

c. 6.6% ΔK/K

d. 7.8% ΔK/K

QUESTION A.11 [1.0]
The source range instrument is reading 50 cps while reactor Shutdown margin is 4.167% ΔK/K. After adding an experiment to the reactor count range decreases to 25 cps. What is the worth of the experiment. (Assume no other reactivity changes, i.e., temperature, rod movement, fuel movement, neutron source movement, etc.)

a. +4.5% ΔK/K

b. -4.5% ΔK/K

c. +8.7% ΔK/K

d. -8.7% ΔK/K

QUESTION A.12 [1.0]
Given: Primary Flow rate through heat exchanger = 1400 GPM; Secondary Flow rate through heat exchanger = 1200 GPM; $\Delta T_{Primary}$ = 13°F and Secondary INLET temperature is 73°F. Which one of the following should be the secondary OUTLET temperature?

a. ≈ 58°F

b. ≈ 62°F

c. ≈ 84°F

d. ≈ 88°F

QUESTION A.13 [1.0]
With the reactor on a constant positive period, which ONE of the following power changes will take the SHORTEST time?

a. 5% power, from 1% to 6% power

b. 10% power, from 10% to 20% power

c. 15% power, from 20% to 35% power

d. 20% power, from 40% to 60% power

QUESTION A.14 [1.0]
Which ONE of the following parameters is MOST significant in determining the differential worth of a control rod?

a. Rod Speed

b. Reactor Power

c. Flux Shape

d. Fuel Loading

QUESTION A.15 [1.0]
Excess reactivity is the amount of reactivity ...

a. associated with samples.

b. required to achieve prompt criticality.

c. available above that required to make the reactor critical.

d. associated with Xenon production

QUESTION A.16 [1.0]
In regard to the Am-Be neutron source: The _____ produced by the decay of the americium are absorbed by the Berilium producing the reaction _______

a. Alphas; $_4Be^9$ (α,n) $_6C^{12}$

b. Betas; $_4Be^9$ (β,n) $_3Li^8$

c. Gammas; $_4Be^9$ (γ,n) 2α

d. Neutrons (from Spontaneous fission); $_4Be^9$ (n,2n) $_4Be^8$

QUESTION A.17 [1.0]
Explain how each of the following condidtions will change reactivity in the core (Increase, Decrease or No Change).

a. Place hollow steel cylinder (filled with air) next to core.

b. Increase Rod Speed.

c. Insert rabbit containing natural uranium into core.

d. Insert rabbit containing water into core.

QUESTION A.18 [1.0]
Given: Scram Setpoint = 1.25 Mwatt. Scram Delay is 1 second. Reactor Operating at 1 Mwatt when a sample inserted into the core results in a Reactor Period of 10 seconds. Which ONE of the following is the PEAK power the reactor will reach prior to shutting down?

a. 1.25 Mwatt

b. 1.38 Mwatt

c. 1.51 Mwatt

d. 1.64 Mwatt

QUESTION A.19 [1.0]
Which ONE of the following describes the MAXIMUM amount of Xenon in the core?

a. 4 to 6 hours following Power Increase, 50% to 100%.

b. 4 to 6 hours following Power Decrease, 100% to 50%.

c. 8 to 12 hours following Power Increase, to 100%.

d. 8 to 12 hours following Power Decrease, from 100%.

(*** END OF SECTION A ***)

QUESTION B.1 [1.0]
Two (2) inches of lead shielding reduce a gamma radiation beam from 400 mr/hr to 200 mr/hr. If you add another four inches of lead (total of 6 inches), what will the new radiation level be?

a. 25 mr/hr

b. 50 mr/hr

c. 75 mr/hr

d. 100 mr/hr

QUESTION B.2 [1.0]
Which one of the following is the reason that Technical Specifications require all grid plate positions to be filled during forced convection cooling mode? An empty grid plate position would ...

A. result in very high flux peaking due to an over abundance of moderator.

B. result in very low flux peaking due to no fuel at that position.

C. result in too little cooling of the core overall due to flow bypassing the rest of the core.

D. result in too much cooling of the local fuel elements.

QUESTION B.3 [2.0]
Match the general area radiation levels listed in column A with the corresponding type of radiation area listed in column B. (Note: Only one answer for each item in column A. Items from column B may be used more than once or not at all.)

	Column A		Column B
A.	15 mRem/hr	1.	Unrestricted Area
B.	65 mRem/hr	2.	Radiation Area
C.	203 mRem/hr	3.	High Radiation Area
D.	520 mRem/hr	4.	Very High Radiation Area

QUESTION B.4 [2.0]
Match the four surveillances listed in column A with the correct Technical Specification definition listed in column B. (Note: Only one answer for each item in column A. Items in column B may be used more than once or not at all.)

Column A		Column B
A.	During shutdown you verify operation of the Log-N channel by verifying power decreases by a factor of 10 in three minutes.	1. Channel Check
B.	During reactor startup you verify proper overlap between the source range and the Log-N channel	2. Channel Test
C.	You verify a temperature channel's operation by replacing the RTD with a precision variable resistance and checking for proper output.	3. Channel Calibration
D.	Based on differences between a calorimetric (heat balance) of the primary system and the readings on Nuclear Instrumentation you make adjustments.	

QUESTION B.5 [1.0]
Which one of the following materials is required to be doubly encapsulated during irradiation by Technical Specifications?

a. Materials which due to internal heating will cause local boiling of coolant.

b. Explosive Materials (must be less than 25 mg).

c. Corrosive Materials

d. A material which will cause a pressure buildup

QUESTION B.6 [2.0]
As Reactor Operator you are responsible for ensuring the correctness of the Irradiation Request Form (IRF). Match the experiment type listed in column A with the corresponding Technical Specification or procedural reactivity limit listed in column B. (Notes: Only one answer for each item in column A. Items in column B, may be used more than once, or not at all. Also "significant reactivity" is defined as amount of reactivity which may be added to core by someone without an RO license.)

	Column A		Column B
a.	Significant Reactivity	1.	0.02% ΔK/K
b.	Single movable	2.	0.025% ΔK/K
c.	Total movable	3.	0.05% ΔK/K
d.	Single Secured	4.	0.1% ΔK/K
e.	Total secured	5.	0.2% ΔK/K
		6.	0.25% ΔK/K
		7.	0.5% ΔK/K
		8.	2.0% ΔK/K
		9.	2.5% ΔK/K
		10.	5.0% ΔK/K

QUESTION B.7 [1.0]
You volunteered to help cleanup an accident at a local Power Reactor facility. During the cleanup you received 4.0 REM. What are your limits with respect to receipt of radiation at U. Mass-Lowell, based on this?

A. No effect on any radiation limits at U. Mass-Lowell. The radiation received during cleanup is tracked only by the power facility and does not count against **ANY** radiation dose which may be received at U. Mass-Lowell.

B. No effect on any radiation limits at U. Mass-Lowell. The radiation dose received during the cleanup is tracked as a Planned Special Exposure, at the facility, and is not applicable to U. Mass-Lowell doses.

C. Decrease in annual and life-time Planned Special Exposure (PSE) limits at U. Mass-Lowell. The radiation dose received during the cleanup is tracked as part of your Planned Special Exposure (PSE) limit.

D. Decrease of annual whole body limit at U. Mass-Lowell by 4 Rem.

QUESTION B.8 [1.0]
Which one of the following statements concerning operation of the crane is **NOT CORRECT**? The crane may be used ...

A. to lower fuel shipping casks into the bulk pool, providing the gate is in place in the stall pool.

B. to move shipping casks over the stall pool.

C to pull equipment sideways.

D. with slings.

QUESTION B.9 [1.0]
When removing a sample from the pneumatic tube receiver, Health Physics coverage is required if the sample reads greater than ...

A. 0.001 rem/hr

B. 0.01 rem/hr

C. 0.1 rem/hr

D. 1 rem/hr

QUESTION B.10 [1.0]
So far this year you've received 3.3 Rem whole body dose. You are required to work on a control drive mechanism in the reactor where there is an average dose rate of 250 mR/hr. Which one of the following times is closest to your stay time without going over? (Assume you are older than 18 years of age.)

A. 3 hours

B. 6 hours

C. 12 hours

D. 18 hours

QUESTION B.11 [1.0]
Who by title(s) authorizes reentry after an evacuation of the containment due to high radiation? (NOTE: I am looking for who is responsible for authorizing reentry, NOT setting reentry requirements.)

A. The Emergency Director on his own.

B. The Radiation Protection Officer on his own.

C. The Emergency Director after consultation with the Radiation Protection Office.

D. The Radiation Protection Officer after consultation with the Operations Office.

QUESTION B.12 [1.0]
The NRC uses four different categories to classify emergencies. Which one of the following classes of emergencies is NOT credible at U. Mass-Lowell?

A. Non-Reactor Safety Related Event

B. Site Area Emergency

C. Alert

D. Notification of Unusual Event

QUESTION B.13 [1.0]
Which ONE of the following conditions will INVALIDATE shutdown margin calculations per SP-26 *Reactivity Evaluations*?

A. Pool Temperature 82°F

B. Regulating rod fully withdrawn

C. Xenon reactivity worth > 0.2% ΔK/K.

D. Addition of a sample worht 0.25% ΔK/K.

QUESTION B.14 [1.0]
Which ONE of the following conditions is an *Abnormal Occurrence* per the Technical Specification definition?

A. Primary Flow trip setpoint at 1400 gpm.

B. A secured experiment worth 0.25% ΔK/K.

C. A mercury thermometer is brought into containment.

D. Operation in Natural Circulation Mode with a pool level of 24 ft. above the top of the core.

QUESTION B.15 [1.0]
An experimenter whichs to perform a routine experiment that he has made minor modifications to. The modified experiment has NOT been reviewed by the Reactor Safety Committee, and the modifications do NOT involve safety considerations. Which ONE of the following is the minimum level of approval necessary to perform the experiment?

A. One licensed Reactor Operator and the Radiation Safety Officer

B. One licensed Reactor Operator and the Reactor Supervisor.

C. The Reactor Supervisor and the Radiation Safety Officer.

D. The Radiation Safety Officer and the Reactor Safety Subcommittee.

QUESTION B.16 [1.0]
During maintenance, a hot spot reads 5,000 mrem/hr at a distance of two feet. How far away must you establish a HIGH Radiation boundary?

A. 4½ feet

B. 15 feet

C. 21 feet

D. 101 feet

QUESTION B.17 [1.0]
The reactor scrams during operations after normal operating hours. Neither you nor the SRO have been able to determine the cause of the scram. What is the minimum level of management who may authorize restart of the reactor under these conditions.

A. The Senior Operator on his/her own.

B. The Senior Operator on consultation with either the Chief Reactor Operator or the Reactor Supervisor.

C. The Chief Reactor Operator after consultation with the Reactor Supervisor.

D. The Reactor Supervisor after consultation with the Facility Director.

(*** END OF SECTION B ***)

QUESTION C.1 [1.0]
Two hours following shutdown, a survey of the Cleanup System demineralizer reads 2 R/hr on contact. Is this reading normal abnormal, and what is the most likely cause?

A. Normal, N^{16}

B. Normal, Fission Products

C. Abnormal, Ar^{41}

D. Abnormal, Fission Products

QUESTION C.2 [1.0]
Which ONE of the following is the main function performed by the DISCRIMINATOR circuit in the Startup Channel?

A. To generate a current signal equal and of opposite polarity as the signal due to gammas generated within the Startup Channel Detector.

B. To filter out small pulses due to gamma interactions, passing only pulses due to neutron events within the Startup Channel Detector.

C. To convert the linear output of the Startup Channel Detector to a logarithmic signal for metering purposes.

D. To convert the logarithmic output of the metering circuit to a δt (delta time) output for period metering purposes.

QUESTION C.3 [1.0]
Which ONE of the following is NOT a Rod Withdrawal Interlock?

A. Low source count rate < 3 cps

B. High flux - 110%

C. Short Period - 15 seconds

D. Source Range Signal/noise ratio of 2

QUESTION C.4 [1.0]
Which one of the following is the correct type of detector used for Nuclear Instrumentation Channel 9 (used as input to the regulating rod automatic control circuit)?

A. Fission Chamber

B. Boron Lined Compensated Ion Chamber

C. Boron Lined Uncompensated Ion Chamber

D. Unlined Ion Chamber

QUESTION C.5 [1.0]
The delay tank is designed to allow two short-lived isotopes to decay off. Which one of the following identifies the two short-lived isotopes?

A. N^{16}, O^{19}

B. N^{16}, Ar^{41}

C. Ar^{41}, O^{19}

D. O^{19}, H^{3}

QUESTION C.6 [1.0]
Which one of the following scrams is disabled by placing the range switch (7S5) in the *0.10 MW* position?

A. Coolant Gate Open (Riser).

B. High Voltage Failure

C. Pool Level

D. Containment Air Leak Doors Open

QUESTION C.7 [1.0]
Which ONE of the following will cause an *ELECTRONIC* SCRAM?

A. Coolant Gate Open

B. High Voltage Failure

C. High Flux

D. High Temperature Primary Coolant

QUESTION C.8 [1.0]
Which one of the following isotopes is sampled for routinely to detect a very small leak from the primary to the secondary system?

A. H^3

B. N^{16}

C. F^{18}

D. Na^{24}

QUESTION C.9 [1.0]
Which one of the following detectors does NOT supply a signal to either the GREA or LREA alarm system?

A. A, Stack Particulate

B. F, Facilities

C. M, Rabbit 1

D. R, Control Room

QUESTION C.10 [1.0]
Which ONE of the following is the gas used, (along with its major drawback) to provide motive force for the pneumatic system?

A. Air, formation of Ar^{41}

B. N_2, corrosive environment, (Nitric Acid)

C. CO_2, formation of N^{16}

D. He, expensive

QUESTION C.11 [1.0]
Which one of the following ventilation valves will fail OPEN on a loss of service air?

A. G, Sanitary System Vent Isolation Valve

B. D, Emergency Exhaust Isolation Valve

C. F, Ventilation Supply Bypass Valve

D. H, Acid Vent (Basement)

QUESTION C.12 [1.0]
Which one of the following is the setpoint for the initiation of the Emergency exhaust system?
$P_{containment} - P_{ambient}$ ...

A. ≥ 0.25 inch Hg

B. ≥ 0.25 inch H_2O

C. ≤ 2 inches Hg

D. ≤ 2 inches H_2O

QUESTION C.13 [1.0]
Thick black smoke is billowing from the cleanup pump. Where will you send the auxiliary operator to deenergize the pump?

A. MCC-1

B. MCC-2

C. ELPL-R1

D. PPL-R1

QUESTION C.14 [1.0]
A small earthquake causes an unisolable leak at the edge of the thermal column, and a loss of normal power. You move the core to the stall end and install the gate. City water is still available. How do you refill the stall pool?

A. Gravity drain from the day tank.

b. Using city water pressure, use normal makeup lineup.

C. You can't, the makeup pump has no power.

D. Gravity drain from the retention tank.

QUESTION C.15 [1.0]
Which one of the following actions will occur due to an increasing temperature detected by the Temperature Controller in the Process Control Cabinet?

A. A motor operated flow control valve in the primary coolant loop will go further open increasing primary mass flow rate through the heat exchanger.

B. A motor operator flow control valve in the primary coolant loop will go further closed decreasing mass flow rate bypassing the heat exchanger.

C. A motor operated flow control valve in the secondary coolant loop will go further open increasing secondary mass flow rate through the heat exchanger.

D. A motor operated flow control valve in the secondary coolant loop will go further closed decreasing secondary mass flow rate through the heat exchanger.

QUESTION C.16 [1.0]
The reactor is operating at 1 Megawatt, when the SECONDARY coolant pump trips on overload. Assuming NO OPERATOR ACTION, which ONE of the following trips would most likely cause a reactor scram?

A. High Flux

B. Short Period

C. High Coolant Inlet Temperature

D. Low Secondary Flow

QUESTION C.17 [2.0]
Match the five control blade withdrawal interlocks in column A with their associated setpoints from column B.

	Column A		Column B
A.	Low Source Range Count _____ cps	1.	3
B.	High Flux _____%	2.	5
C.	Short Period _____ seconds	3.	10
D.	Low Flux _____%	4.	15
E.	Time delay block _____ seconds	5.	110

QUESTION C.18 [2.0]
Match the Radiation Detection Systems in Column A with its corresponding detector type from Column B

	Column A		Column B
A.	Continuous Air Monitors	1.	Proportional Counter
B.	Stack Effluent Monitor (Gaseous)	2.	Geiger-Müeller
C.	Stack Effluent Monitor (Particulate)	3.	Scintillation
D.	Bridge Area Radiation Monitor	4.	Ion Chamber

(*** END OF SECTION C ***)
(***** END OF EXAMINATION *****)

ANSWER A.1
b
REFERENCE A.1
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 3.3. The Chain Reactor, Neutron Multiplication, Reactivity and the Six Factor Formula

ANSWER A.2
c
REFERENCE A.2
+9~~ºF~~ * 0.05% ΔK/K/~~ºF~~ = 0.45% ΔK/K which implies that the rod must insert -0.45 ΔK/K.
-0.45 ~~ΔK/K~~ ÷ 0.1 ~~ΔK/K~~/inch = - 4.5 inches or 4½ inches inward.
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, §§ 6.4.1 Moderator Temperature Coefficient, and 7.2 Differential Rod Worth.

ANSWER A.3
a
REFERENCE A.3
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 2.4.5, Neutron Interactions with Matter.

ANSWER A.4
QUESTION DELETED PER FACILITY COMMENT
REFERENCE A.4
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 2.5, Table 2.3.

ANSWER A.5
d
REFERENCE A.5
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, §

ANSWER A.6
c
REFERENCE A.6
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 5.3

ANSWER A.7
b
REFERENCE A.7
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, §

ANSWER A.8
c
REFERENCE A.8
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, §§ 3.2.2 & 3.2.3

ANSWER A.9
b
REFERENCE A.9
SDM = 1-K_{eff}/K_{eff} = (1 - 0.85)/0.85 = (0.15/0.85) = .1765 ΔK/K = 17.65% ΔK/K
Adding 17.6% ΔK/K will reduce the SDM, 17.65% ΔK/K - 17.6% ΔK/K = 0.05%Δ K/K.
K_{eff} = 1/(1 + SDM) = 1/(1 + 0.0005) = 1/1.0005 = 0.9995

ANSWER A.10
c
REFERENCE A.10
(11.4% - 4.2% - 0.6%)ΔK/K = 6.6% ΔK/K

ANSWER A.11
b
REFERENCE A.11
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 5.7 Problems
Initial K_{eff} = 1/(1 + 0.0417) = 0.96 $CR_1/CR_2 = (1 - K_{eff2})/(1 - K_{eff1})$
50/25 = (1 - K_{eff2})/(1 - 0.96) 2 * 0.04 = 1 - K_{eff2}
K_{eff2} = 1 - 0.08 = 0.92
SDM = (1 - 0.92)/0.92 =0.08/0.92 = 8.7% ΔK/K.
Worth of experiment is: .0417 - 0.0870 = -0.0453 = 4.5% ΔK/K

ANSWER A.12
d **ANSWER CHANGED PER FACILITY COMMENT**
REFERENCE A.12

$$\dot{m}_{pri}\, c_p\, \Delta T_{pri} = \dot{m}_{sec}\, c_p\, \Delta T_{sec}$$

ΔT_{sec} = 1400/1200 * 13°F = 7/6 * 13 = 15.2°F T_{OUT} = 73 + 15.2 = 88.2

ANSWER A.13
d
REFERENCE A.13
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 4,4(b); p. 4-11
ANSWER A.14
c
REFERENCE A.14
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 7.2, p. 7-4.
ANSWER A.15
c
REFERENCE A.15
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 6.2.2, p. 6-6
ANSWER A.16
a
REFERENCE A.16
Burn, R. R., *Introduction or Nuclear Reactor Operations,* June 1984, § 5.2, also Chart of the Nuclides.

ANSWER A.17
QUESTION DELETED PER FACILITY COMMENT
REFERENCE A.17
NRC Examination Bank Question adminsitered August, 1988.

ANSWER A.18
b
REFERENCE A.18
$P = P_0 e^{T/\tau}$; $P = 1.25 * e^{1/10} = 1.25 * 1.1052 = 1.38$
NRC Examination Bank Question asked March, 1994.
ANSWER A.19
d
REFERENCE A.19
Burn, R. R., *Introduction or Nuclear Reactor Operations*, June 1984, § 8.4, pp. 8-12 to 8-19.

(*** END OF SECTION A ***)

ANSWER B.1
b
REFERENCE B.1
Given in first sentence: 2" = ½-thickness. Given 3 ½-thicknesses, $I = I_0 \frac{1}{2}^3$ = 400/8 = 50 mr/hr

ANSWER B.2
c
REFERENCE B.2
U. Mass-Lowell, Tech. Spec. § 3.1 BASES # 3, p. IV-15

ANSWER B.3
a, 2; b, 2; c, 3; d, 3; **ANSWER TO PART d CHANGED PER FACILITY COMMENT**
REFERENCE B.3
10 CFR 20.1 Definitions

ANSWER B.4
a, 1; b, 1; c, 2; d, 3
REFERENCE B.4
U. Mass-Lowell, Tech Spec. §§ 1.2, 1.3 & 1.4

ANSWER B.5
c
REFERENCE B.5
U. Mass-Lowell, Tech. Spec. § 3.6, pp. IV-24 through IV-26.

ANSWER B.6
a, 1; b, 4; c, 7; d, 7; e, 9
REFERENCE B.6
U. Mass-Lowell, Tech. Spec. § 3.1, Table on page IV-14.

ANSWER B.7
c or a **SECOND CORRECT ANSWER ADDED PER FACILITY COMMENT**
REFERENCE B.7
10 CFR 20.1206, and 20.1201(b).

ANSWER B.8
b
REFERENCE B.8
U. Mass-Lowell, S.P. § p. 4.6

ANSWER B.9
d
REFERENCE B.9
U. Mass-Lowell, RO-4 § 4.1.7, p. 4-2

ANSWER B.10
5.0 - 3.3 = 1.7 Rem allowable 1.7 Rem/.25 Rem/hr 6.8 ≈ 6
REFERENCE B.11
10 CFR 20.1201

ANSWER B.11
c or a **SECOND CORRECT ANSWER ADDED PER FACILITY COMMENT**
REFERENCE B.11
U. Mass-Lowell, EP 3.4 *Authorization for Reentry.*

ANSWER B.12
b
REFERENCE B.12
U. Mass-Lowell, Emergency Plan §§ 4.0 through 4.5

ANSWER B.13
c
REFERENCE B.13
Special Procedure SP-26, *Reactivity Evaluation,* p. SP-26-1

ANSWER B.14
QUESTION DELETED PER FACILITY COMMENT
REFERENCE B.14
Technical Specification 1.0 *Definitions*; Standing Order #1, Materials Prohibited in the Reactor Containment.

ANSWER B.15
c
REFERENCE B.15
U. Mass-Lowell,, Technical Specification 6.8 *roval of Experiments*

ANSWER B.16
b
REFERENCE B.16
$DR_1/DR_2 = Dist_2^2/Dist_1^2$ (5000/100) rem/hr = $X^2/2^2$ 50 * 4 = X^2 = 200
X = 14.1

ANSWER B.17
b
REFERENCE B.17
UMLR RO-7, *Reactor Shutdown,* § 7.32.4, pp. RO7-2&3.

(*** END OF SECTION B ***)

ANSWER C.1
d
REFERENCE C.1
Modification of NRC Examination Bank Question asked August 1988, also; U. Mass. Lowell Reactor, FSAR § 8.1.3.

ANSWER C.2
b
REFERENCE C.2
U. Mass. Lowell Reactor,

ANSWER C.3
d
REFERENCE C.3
U. Mass. Lowell Reactor RO-9 System Checkout Procedures

ANSWER C.4
b
REFERENCE C.4
U. Mass. Lowell Reactor, SAR §§ 4.4.12 & 4.4.14

ANSWER C.5
a **ANSWER CHANGED PER FACILITY COMMENT**
REFERENCE C.5
U. Mass. Lowell Reactor, FSAR p. 4-22

ANSWER C.6
a
REFERENCE C.6
U. Mass. Lowell Reactor, RO-9 *Reactor and Control System Checkout,* § 9.2.2(d)

ANSWER C.7
c
REFERENCE C.7
U. Mass. Lowell Reactor, FSAR § 4.4.15.2, p. 4-74

ANSWER C.8
d
REFERENCE C.8
U. Mass. Lowell Reactor, Study Guide for Key Access and Introduction to Operator Training at the University of Massachusetts Lowell Research Reactor, Section dealing with Secondary Cooling System.

ANSWER C.9
b
REFERENCE C.9
U. Mass. Lowell Reactor, Study Guide for Key Access and Introduction to Operator Training at the University of Massachusetts Lowell Research Reactor, Section dealing with Radiation Monitors.

ANSWER C.10
a
REFERENCE C.10
U. Mass. Lowell Reactor, FSAR § 4.3.3, pp. 4-34 — 4-36

ANSWER C.11
c
REFERENCE C.11
U. Mass. Lowell Reactor, FSAR, § 3.4.2.2

ANSWER C.12
b
REFERENCE C.12
U. Mass. Lowell Reactor, SAR pp. 3-10, 3-21, 3-24 & 3-25, also NRC Exam Bank question on 09/17/1996 examination.

ANSWER C.13
a
REFERENCE C.13
U. Mass. Lowell Reactor, Study Guide for Key Access and Introduction to Operator Training at the University of Massachusetts Lowell Research Reactor, Section dealing with Electrical System, fig. 5-3.

ANSWER C.14
c or b **SECOND CORRECT ANSWER ADDED PER FACILITY COMMENT**
REFERENCE C.14
U. Mass. Lowell Reactor, CAF

ANSWER C.15
c
REFERENCE C.15
U. Mass. Lowell Reactor, , Study Guide for Key Access and Introduction to Operator Training at the University of Massachusetts Lowell Research Reactor, Section dealing with Secondary Cooling System.

ANSWER C.16
c
REFERENCE C.16
Modification of NRC Examination bank question administered August 1988.

ANSWER C.17
a,1; b,5; c,4; d,2; e, 3
REFERENCE C.17
Modified NRC Examination Bank Question administered August, 1988

ANSWER C.18
a, 2; b, 2; c, 3; d, 4
REFERENCE C.18
NRC Examination Bank Question asked March, 1993.

(*** END OF SECTION C ***)
(***** END OF EXAMINATION *****)

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

FACILITY: U. Massachusetts-Lowell

REACTOR TYPE: GE POOL

DATE ADMINISTERED: 1996/09/23

REGION: I

CANDIDATE: ______________________

INSTRUCTIONS TO CANDIDATE:

Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in paren-theses for each question. A 70% overall 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.	PLANT 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 <u>only</u> 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 you 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

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

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

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

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

$$\lambda_{eff} = 0.1 \text{ seconds}^{-1}$$

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

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

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

$$M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}}$$

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

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

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

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

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

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

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

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

$$T_{½} = \frac{0.693}{\lambda}$$

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

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

$$DR_1 d_1^2 = DR_2 d_2^2$$

$$DR = \frac{6CiE(n)}{R^2}$$

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

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

1 Curie = 3.7×10^{10} dis/sec

1 kg = 2.21 lbm

1 Horsepower = 2.54×10^3 BTU/hr

1 Mw = 3.41×10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_p = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

ANSWER SHEET

A.1 a b c d ___

A.2 a b c d ___

A.3 a b c d ___

A.4 a b c d ___

A.5 a b c d ___

A.6 a b c d ___

A.7 a b c d ___

A.8 a b c d ___

A.9 a b c d ___

A.10 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

A.17a increase decrease no change ___

b increase decrease no change ___

c increase decrease no change ___

d increase decrease no change ___

A.18 a b c d ___

A.19 a b c d ___

ANSWER SHEET

B.1 a b c d ___

B.2 a b c d ___

B.3a 1 2 3 4 ___

b 1 2 3 4 ___

c 1 2 3 4 ___

d 1 2 3 4 ___

B.4a 1 2 3 ___

b 1 2 3 ___

c 1 2 3 ___

d 1 2 3 ___

B.5 a b c d ___

B.6a 1 2 3 4 5 6 7 8 9 10 ___

b 1 2 3 4 5 6 7 8 9 10 ___

c 1 2 3 4 5 6 7 8 9 10 ___

d 1 2 3 4 5 6 7 8 9 10 ___

e 1 2 3 4 5 6 7 8 9 10 ___

B.7 a b c d ___

B.8 a b c d ___

B.9 a b c d ___

B.10 a b c d ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16 a b c d ___

B.17 a b c d ___