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

REPORT NO.: 50-157/OL-99-01

FACILITY DOCKET NO.: 50-157

FACILITY LICENSE NO.: R-80

FACILITY: Cornell University TRIGA

EXAMINATION DATES: Sept. 29 through Oct. 1, 1999

EXAMINER: Paul Doyle, Chief Examiner

SUBMITTED BY: Paul Doyle, Chief Examiner — 10/15/99 Date

SUMMARY:

During the week of September 27, 1999, the NRC administered initial Operator Licensing Examinations to two Reactor Operator Candidates. Both Candidates passed all portions of the examinations. The reactor supervisor reviewed the written examination prior to administration, and changes were made prior to administration. All changes have been incorporated into the examination included with this report. The facility had no post administration comments.

ENCLOSURE 1

REPORT DETAILS

1. Examiners:
   PDoyle, Chief Examiner

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	2/0	0/0	2/0
Operating Tests	2/0	0/0	2/0
Overall	2/0	0/0	2/0

3. Exit Meeting:
   Paul Doyle, NRC, Examiner
   Scott Lassell, Reactor Director, Cornell University TRIGA

During the exit meeting the examiner discussed the difficulty of preparing an examination with the material provided. First the facility sent a copy of the Safety Evaluation Report (SER) instead of the Safety Analysis Report (SAR), as requested in the initial scheduling letter. The problem with sending the SER is that it has describes the systems in much less detail than the SAR. In addition, so much of the material in the SER, (and this is also true of the SAR) is out of date. Examples of information in the material that was out of date are descriptions of:

- construction of Aluminum fuel elements (no longer in use at the facility),
- a lazy susan experiment facility (no longer in use at the facility),
- an automatic rod control circuit (no longer in use at the facility), and
- four Nuclear Instrumentation channels, replaced by three new channels not described in the material provided.

Facility management has to do a better job of providing the examiner with up-to-date, appropriate material.

CORNELL UNIVERSITY
With Answer Key

UNITED STATES NUCLEAR REGULATORY COMMISSION

OPERATOR LICENSING EXAMINATION

September 29, 1999

Enclosure 2

QUESTION (A.1) [1.0 point]
Core excess reactivity changes with ...

a. fuel element burnup

b. control rod height

c. neutron energy level

d. reactor power level

QUESTION (A.2) [1.0 point]
Inserting a control rod predominantly affects K_{eff} by changing the ...

a. fast fission factor

b. thermal utilization factor

c. neutron reproduction factor

d. resonance escape probability.

QUESTION (A.3) [2.0 points, ½ point each]
Match each term in column A with the correct definition in column B.

	Column A		Column B
a.	Prompt Neutron	1.	A neutron in equilibrium with its surroundings.
b.	Fast Neutron	2.	A neutron born directly from fission.
c.	Thermal Neutron	3.	A neutron born due to decay of a fission product.
d.	Delayed Neutron	4.	A neutron at an energy level greater than its surroundings.

QUESTION (A.4) [2.0 point, ½ each]
Define each of the following as either conduction (CON), natural convection (NC), forced convection (FC)or radiative heat transfer (RAD). Transfer of heat...

a. within the fuel

b. within the clad

c. from the clad to the pool

d. from the pool to the chilled water system.

QUESTION (A.5) [1.0 point]
You enter the control room and note that all nuclear instrumentation show a steady neutron level, and no rods are in motion. Which ONE of the following conditions **CANNOT** be true?

a. The reactor is critical.

b. The reactor is subcritical.

c. The reactor is supercritical.

d. The neutron source has been removed from the core.

QUESTION (A.6) [1.0 point]
Which ONE of the following is an example of (β) decay?

a. ${}_{35}Br^{87} \rightarrow {}_{33}As^{83}$

b. ${}_{35}Br^{87} \rightarrow {}_{35}Br^{86}$

c. ${}_{35}Br^{87} \rightarrow {}_{34}Se^{86}$

d. ${}_{35}Br^{87} \rightarrow {}_{36}Kr^{87}$

QUESTION (A.7) [1.0 point]
The delayed neutron precursor (β) for U^{235} is 0.0065. However, when calculating reactor parameters you use β_{eff} with a value of ~0.0070. Why is β_{eff} larger than β?

a. Delayed neutrons are born at higher energies than prompt neutrons resulting in a greater worth for the neutrons.

b. Delayed neutrons are born at lower energies than prompt neutrons resulting in less leakage during slowdown to thermal energies.

c. The fuel also contains U^{238} which has a relatively large β for fast fission.

d. U^{238} in the core becomes Pu^{239} (by neutron absorption), which has a higher β for fission.

QUESTION (A.8) [1.0 point]
The difference between a moderator and a reflector is that a reflector ...

a. increases the fast non-leakage factor and a moderator increases the thermal utilization factor.

b. increases the neutron production factor and a moderator increases the fast fission factor.

c. increases the neutron production factor and a moderator decreases the thermal utilization factor.

d. decreases the fast non-leakage factor and a moderator increases the thermal utilization factor.

QUESTION (A.9) [1.0 point]
Which of the following atoms will cause a neutron to lose the most energy during an elastic scattering reaction?

a. O^{16}

b. C^{12}

c. U^{235}

d. H^{1}

QUESTION (A.10) [1.0 point]
The reactor is critical at a milliwatt with the regulating rod at position X. You withdraw the reg rod to increase power to a watt. To stabilize power at this level you must insert the reg rod to ...

a. a position lower than X.

b. position X.

c. a position slightly higher than X.

d. all the way into the core.

QUESTION (A.11) [1.0 point]
Which ONE of the following statements correctly describes the concentration of Xenon in the core following a scram from extended operation at 10 Megawatts? Xenon concentration ...

a. initially decreases due to the loss of Iodine production, then increases to maximum concentration.

b. decreases to a Xenon free condition in approximately 10 hours.

c. increases to maximum in approximately 10 hours due to the reduction in burnup.

d. remains at equilibrium, because without fission no new Xenon is being produced.

QUESTION (A.12) [1.0 point]
Which ONE of the following is the **MAJOR** source of energy released during fission? The Energy of ...

a. prompt gamma rays.

b. capture gammas.

c. Beta particles.

d. fission fragments.

QUESTION (A.13) [1.0 point]
Five minutes following a reactor shutdown, the source range monitor is reading 3×10^6 counts/minute. Which ONE of the following is the count rate you would expect to see three minutes later

a. 10^6 counts/minute

b. 8×10^5 counts/minute

c. 5×10^5 counts/minute

d. 3×10^5 counts/minute

QUESTION (A.14) [1.0 point]
The reactor is on a **CONSTANT** positive period. Which ONE of the following power changes will take the **LONGEST** time to complete?

a. 5%, from 95% to 100%

b. 10%, from 80% to 90%

c. 15%, from 15% to 30%

d. 20%, from 60% to 80%

QUESTION (A.15) [1.0 point]
The reactor is shutdown with a shutdown margin of 12%. An experimenter inserts an experiment into the center thimble, and NLW indication increases from 100 CPM to 200 CPM. What is the worth of the experiment?

a. 12.8% $\Delta K/K$

b. 9.6% $\Delta K/K$

c. 6.4% $\Delta K/K$

d. 3.2% $\Delta K/K$

QUESTION (A.16) [1.0 point]
The term ***PROMPT JUMP*** refers to ...

a. the instantaneous change in power due to raising a control rod.

b. a reactor which is critical due to both prompt and delayed neutrons.

c. a reactor whic' has attained criticality on prompt neutrons alone.

d. a negative reactivity insertion which is greater than β_{eff}.

QUESTION (A.17) [1.0 point]
INELASTIC SCATTERING is the process by which a neutron collides with a nucleus and ...

a. recoils with the same kinetic energy it had prior to the collision

b. recoils with less kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

c. is absorbed, with the nucleus emitting a gamma ray.

d. recoils with a higher kinetic energy than it had prior to the collision with the nucleus emitting a gamma ray.

QUESTION (A.18) [1.0 point]
The **PRIMARY** reason that a neutron source is installed in the reactor is to ...

a. allow for testing and irradiation of experiments when the core is shutdown.

b. supply the neutrons required to start the chain reaction for subsequent reactor startups.

c. provide a neutron level high enough to be monitored for a controlled reactor startup.

d. increase the excess reactivity of the reactor which reduces the frequency for refueling.

QUESTION (B.1) [2.0 points, ½ point each]
Identify each of the actions listed below as either a Channel Check (Check), a Channel Test (Test), or a Channel Calibration (Cal).

a. Prior to startup you place a known radioactive source near a radiation detector, noting meter movement, and alarm function operation.

b. During startup you compare all of your nuclear instrument channels ensuring they track together.

c. At power , you perform a heat balance (calorimetric) and determine the need to adjust Nuclear Instrumentation readings.

d. During reactor shutdown you note -80 second period on nuclear instrumentation.

QUESTION (B.2) [1.0 point]
In order to transfer waste water out of the building, you must have permission from (Lowest Level of permission).

a. On-duty Health Physicist

b. On-duty Responsible Person

c. Reactor Supervisor

d. University Radiation Safety Office.

QUESTION (B.3) [1.0 point]
A radioactive source gives a dose rate of 50 mR/hr. Adding a thin lead shield reduces the dose rate to 25 mR/hr. If you **ADD** two more thin lead shields of the same thickness as the first the new dose rate will be ...

a. 12½

b. 6¼

c. 3⅛

d. 1⁷⁄₈

QUESTION (B.4) [2.0 points, ½ point each]
Identify each of the following as either a Safety Limit (SL), Limiting Safety System Setting (LSSS), or a Limiting Condition for Operation (LCO)

a. Prior to pulsing steady-state power level of the reactor is not greater than 10 kW.

b. For a core containing an aluminum-clad, low hydride thermocouple fuel element, shall not exceed 230°C.

c. The temperature in a stainless-steel-clad high-hydride fuel element shall not exceed 1000°C.

d. During steady-state operation a minimum of two Reactor Power Level Channels shall be operable.

QUESTION (B.5) [2.0 points, ½ point each]
The appropriate federal regulation contains many requirements for Operator Licenses, match each of the requirements listed in column A with it's appropriate time period in column B. (Note: Periods from column B may be used more than once or not at all.)

Column A (Requirements)	Column B (Years)
a. License Renewal	½
b. Requalification Written Examination	1
c. Requalification Evaluation	2
d. Medical Examination	4
	6

QUESTION (B.6) [1.0 points, ¼ point each]
Identify each of the radioisotopes in column A with its PRIMARY source (irradiation of air or water, or fission product).

a. ${}_{1}H^{3}$

b. ${}_{18}Ar^{41}$

c. ${}_{7}N^{16}$

d. ${}_{54}Xe^{135}$

QUESTION (B.7) [2.0 points, ½ point each]
Match the type of radiation in column A with its associated Quality Factor (10CFR20) from column B.

Column A	Column B
a. alpha	1
b. beta	2
c. gamma	5
d. neutron (unknown energy)	10
	20

QUESTION (B.8) [1.0.]
Which ONE of the following is the lowest level of management who may authorize the use of the safety rod vice the shim rod to attain criticality according to OP 100?

a. Any Licensed Reactor Operator (RO)

b. Any Licensed Senior Operator (SRO)

c. The Responsible Person (RP) on duty.

d. The Reactor Supervisor

QUESTION (B.9) [1.0 point]
Which ONE of the following methods is the **PREFERRED** method for reducing activity below the limits prior to disposing of radioactive liquid waste?

a. Transfer the water to a distillation unit for evaporation of the liquid. The solid distillate is disposed of as solid waste.

b. Chemically treat the waste so that the radionuclides will form a precipitate. Then pump the water through filters to lower the activity.

c. Maintain the liquid in tank(s) until the radioactivity has decayed low enough for normal liquid waste tank pumping.

d. Add fresh water to the tank to reduce the concentration low enough to allow pumping.

QUESTION (B.10) [1.0 point, ¼ each]
Identify the Cornell Emergency Classifications from most (4) to least (1) significant.

a. Emergency Alert

b. Facility Emergency

c. Personnel Emergency

d. Reactor Emergency

QUESTION (B.11) [1.0 point]
The MAXIMUM K_{eff} for fuel stored at University of Cornell is ...

a. 0.80

b. 0.85

c. 0.90

d. 0.95

QUESTION (B.12) [1.0 points, ¼ point each]
Match the Federal regulation chapter in column A with the requirements covered.

	Column A		Column B
a.	10 CFR 20	1.	Operator Licenses
b.	10 CFR 50	2.	Facility Licenses
c.	10 CFR 55	3.	Radiation Protection
d.	10 CFR 73	4.	Special Nuclear Material

QUESTION (B.13) [1.0 point]
The Emergency Response Kit is located ...

a. in the TRIGA control room

b. in the dosimetry room

c. in the Isotope and Fuel Storage room

d. in the ZPR control room

QUESTION (B.14) [1.0 point]
According to OP 102, the maximum number of pulses which may be performed in an hour is ...

a. 6

b. 9

c. 12

d. 15

QUESTION (B.15) [1.0 point]
Per the definition in the Emergency Plan, Emergency Action Level(s) is (are) ...

a. the person or persons appointed by the Emergency Coordinator to ensure that all personnel have evacuated the facility or a specific part of the facility.

b. a condition or conditions which call(s) for immediate action, beyond the scope of normal operating procedures, to avoid an accident or to mitigate the consequences of one.

c. projected radiological dose or dose commitment values to individuals that warrant protective action following a release of radioactive material.

d. instrument readings, observations; calculations or emergency judgements which define an emergency or call for a specific response to that emergency.

QUESTION (B.16) [1.0 point]
Annual maintenance was last performed on the control rods on October 31, 1998. The last date annual maintenance may be performed on the system without being late is ...

a. October 31, 1999

b. November 30, 1999

c. December 31, 1999

d. January 31, 2000

QUESTION (C.1) [1.0 point]
How is Reactor Coolant temperature controlled?

a. Varying reactor loop flow by varying speed of the primary pump.

b. Varying reactor loop flow by varying the position of butterfly valve V-1.

c. Varying secondary loop flow by varying the speed of the secondary pump.

d. Varying secondary loop flow by varying the position of butterfly valve V-11.

QUESTION (C.2) [2.0 points, ½ each]
Match each component in the water treatment system (in column A) with its primary function (listed in column B).

Column A	Column B
a. Demineralizer	1. to remove impurities in the city water supply
b. Water Softener	2. to remove ionic impurities in the water
c. Carbon Filter	3. to remove particulate impurities in the water
d. Skimmer	4. to remove impurities floating on the top of the pool.

QUESTION (C.3) [1.0 point]
An alarm on which ONE of the following radiation monitoring systems will cause the ventilation system to isolate automatically?

a. Stack Gas Monitor

b. Continuous Air Particulate Monitor

c. Center Channel gamma Monitor

d. West Bay Area Radiation Monitor

QUESTION (C.4) [2.0 points, ½ point each]
Match each of the channels listed in column A with the appropriate type of Detector listed in column B.

Column A (NI Channel)	Column B (Neutron Detector)
a. NLW	1. Fission Chamber
b. NMP	2. Compensated Ion Chamber
c. NPP	3. BF_3 Proportional Counter
d. Continuous Air Monitor	4. Uncompensated Ion Chamber
	5. Geiger Counter

QUESTION (C.5) [1.0 point]
In order to prevent leakage from the primary system to the secondary system, the primary pump will shut off if the pressure in the ...

a. primary system exceeds 32 psig.

b. secondary system exceeds 100 psig.

c. secondary system decreases to 50 psig.

d. primary system decreases to 10 psig.

QUESTION (C.6) [1.0 point]
What is the purpose of the angled return (diffuser) on the Primary system return piping? To reduce radiation due to ...

a. H^3

b. N^{16}

c. Ar^{41}

d. I^{131}

QUESTION (C.7) [1.0 point]
Which ONE of the following is the neutron absorbing medium in the control rods?

a. Hafnium

b. Boron

c. Xenon

d. Samarium

QUESTION (C.8) [1.0 point]
Which ONE of the following is the method used to generate rod position indication for the standard (non-pulsing) control rods?

a. As the shim button is depressed it energizes a small electrical syncro motor which is electrically connected to the indication (servo motor).

b. The rod moves a slug into or out of an electrical coil generating a position signal.

c. A series of 500 magnetic switches open or close as the rod moves.

d. A helipot connected to the pinion drive generates a position signal.

QUESTION (C.9) [1.0 point]
Which ONE of the following Nuclear Instrumentation Channels also supplies Period Indication?

a. DELETED

b. NLW

c. NMP

d. NPP

QUESTION (C.10) [1.0 point]
Which ONE of the following actions were performed to prevent siphoning of water out of the TRIGA pool?

a. Vacuum breakers were installed on all piping penetrating the pool.

b. Holes were drilled on all pipes penetrating the pool at 1 foot below minimum operating level of 18½ feet.

c. Automatic closure of air operated valves on low primary pressure.

d. Automatic opening of an Anti-Siphon System valve.

QUESTION (C.11) [1.0 point]
The ventilation system has valves which shut on containment isolation. Which ONE of the following is the method used to shut these valves? The valves are ...

a. air motor operated, with their own emergency air supply tanks.

b. motor operated, with power supplied from emergency batteries.

c. held open by solenoid, which when deenergized, the door closes via spring.

d. held open by air pistons, which when vented, close via spring.

QUESTION (C.12) [1.0 point]
Which ONE of the following SCRAMS is not required by Technical Specifications?

a. NMP

b. Fuel Element Temperature

c. Manual Button

d. Low Voltage in the Scram Relay Circuit.

QUESTION (C.13) [1.0 point]
What is the maximum power level operation allowed without the diffuser on-line?

a. 50 Kwatts

b. 100 Kwatts

c. 150 Kwatts

d. 250 Kwatts

QUESTION (C.14) [1.0 point]
Which ONE of the following beamports does NOT have a sliding lead door?

a. 4E

b. 6E

c. 6SE

d. 3E

QUESTION (C.15) [1.0 point]
The motive force used to propel the "Rabbit" into and out of the core is ...

a. air

b. CO_2

c. N_2

d. He

QUESTION (C.16) [1.0 point]
Based on nominal flow and temperatures, how long may the reactor be run at 250 Kwatts continuously without exceeding the Technical Specification limit of 130°F?

a. Less than 8 hours

b. Between 8 and 16 hours

c. between 24 and 48 hours

d. forever, the temperature will max out below the limit.

QUESTION (C.17) [1.0, point]
The source used to calibrate Radiation Monitoring Equipment is ...

a. H^3

b. Ar^{41}

c. Fe^{58}

d. Co^{60}

QUESTION (C.18) [1.0 point]
When performing a power calibration using the Calorimetric Method (OP 204), pool water mixing is accomplished by:

a. Running the primary system, with the secondary system secured.

b. Running the primary system with the secondary system secured.

c. Running a small boat propeller at 500 RPM.

d. Natural convection flow due to heat output from the core.

A.1 a
REF: GA Operator Training Manual Chapt VI, § 6.1.14

A.2 b
REF: GA Operator Training Manual Chapt VI, §§ 6.1.13 and 6.1.15

A.3 a, 2; b, 4; c, 1; d, 3
REF: GA Operator Training Manual Chapt VI, §§ 6.1.11 and 6.2.2

A.4 a, CON; b, CON; c, NC; d, FC
REF: Rewrite of NRC examination question administered October, 1986

A.5 c
REF: Standard NRC question

A.6 d
REF: Standard NRC question

A.7 b
REF: GA Operator Training Manual Chapt VI, §6.2.2, 1st ¶m pg. 10.

A.8 a
REF: GA Operator Training Manual Chapt VI, §§ 6.1.11 and 6.1.12.

A.9 d
REF: GA Operator Training Manual Chapt VI, § 6.1.11, 2nd ¶

A.10 b
REF: Standard NRC Question

A.11 c
REF: GA Operator Training Manual Chapt VI, § 6.3.7.

A.12 d
REF: Standard NRC question

A.13 d
REF: GA Operator Training Manual Chapt VI, § 6.2.5, Equation 6-11 and last paragraph in section 6.2.5.

A.14 c
REF: GA Operator Training Manual Chapt VI, § 6.2.5, Equation 6-11.

A.15 c
REF: GA Operator Training Manual Chapt VI, § 6.2.5, 1st ¶, pg. 15

A.16 a
REF: GA Operator Training Manual Chapt VI, § 6.2.5

A.17 b
REF: GA Operator Training Manual Chapt VI, § 6.2.7,

A.18 c
REF: GA Operator Training Manual Chapt VI, §

B.1 a, Test; b, Check; c, Cal; d, Check
REF: Technical Specifications, § 1, Definitions

B.2 d
REF: OP 100, § I.C, 1st ¶ on page 3.

B.3 b
REF:

$$I = I_0\left(\frac{1}{2}\right)^3 = I_0\left(\frac{1}{8}\right) = \frac{50}{8} = 6\frac{1}{4}$$

B.4 a, LCO; b, LSSS; c, SL; d, LCO
REF: T.S. §§ a-3.3.a and 3.4.a, b-2.2.a/b, c-2.1.c, d-3.1

B.5 a, 6; b, 2; c, 1; d, 2
REF: 10CFR55

B.6 a, water ; b, air; c, water; d, fission product
REF: Standard NRC question

B.7 a, 20; b, 1; c, 1; d, 10
REF: 10CFR20.100x

B.8 c
REF: OP 100, § B.4.

B.9 c
REF: SER § 11.2.2 1ST ¶ on page 11-2.

B.10 a, 2; b, 4; c, 1; d, 3
REF: Emergency Plan, § 4.0

B.11 a
REF: T.S. 5.3(1)

B.12 a, 3; b, 2; c, 1; d, 4.
REF: Title 10 to the Code of federal Regulations.

B.13 b
REF: Emergency Director Checklist first page.

B.14 c
REF: OP 102 § II.2.

B.15 d
REF: Emergen' Plan, § 2.0 Definitions.

B.16 c
REF: T.S. 4.2 Control Rods

C.1 d
REF: *SER, Figure 5.1 on page* 5-3, and OP500 Figure 1.

C.2 a, 2; b, 1; c, 3; d, 4
REF: Standard NRC question

C.3 a
REF: Facility supplied figure *Radiation Hazard Alarm and Vent Circuits,* drawn by P. Craven 4-2-76, as verified by Telephone call to Reactor Supervisor.

C.4 a, 1; b, 2; c, 4; d, 5
REF: SER, Figure 7.1, pg. 7-4.

C.5 c
REF: SER, § 5.2 2nd ¶.

C.6 b
REF: SER § 5.4, and telephone conversation with Reactor Supervisor, confirming the diffuser is installed.

C.7 b
REF: SER, § 4.1.2.

C.8 d
REF: SER § 4.7.1.

C.9 b or a
REF: Reactor Physical Plant § 5.2.2.

C.10 b
REF: OP-500, page 2, 3rd Paragraph.

C.11 d
REF: OP 302, § IV.1.a.

C.12 d
REF: SER § 7.6. 2nd ¶

C.13 b
REF: OP500, § IV.A.2.

C.14 d
REF: SER, Figure 4.1, and OP101, step 25.

C.15 a
REF: SER, § 10.1.2

C.16 d
REF: OP 500 § I 1st ¶, also figure 2.

C.17 d
REF: OP205, § III 1st ¶

C.18 c
REF: OP 204, § IV,1.

Calculation for Question A.15

$$K_{eff_1} = \frac{1}{1+SDM} = \frac{1}{1+0.12} = \frac{1}{1.12} = 0.892857$$

$$CR_1\left(1-K_{eff_1}\right) = CR_2\left(1-K_{eff_2}\right) \qquad 1-K_{eff_2} = \left(1-K_{eff_1}\right)\left(\frac{CR_1}{CR_2}\right)$$

$$1-K_{eff_2} = \frac{100}{200}(1-0.892857) = \frac{1}{2}(0.107143) = 0.0535715$$

$$K_{eff_2} = 1-0.0535715 = 0.9464286$$

$$\Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{K_{eff_2}\ K_{eff_1}} = \frac{0.9464284-0.892857}{(0.9464284)\ (0.892857)} = 0.063964$$

or about 6.4% ΔK/K

Cornell University

September 1999 Examination

Question	Answer	Answer	Martin Moravek		Martin Skup		
1	a		a	1	a	1	100.0%
2	b		b	1	b	1	100.0%
3a	2		2	0.5	2	0.5	100.0%
3b	4		4	0.5	4	0.5	100.0%
3c	1		1	0.5	1	0.5	100.0%
3d	3		3	0.5	3	0.5	100.0%
4a	CON		CON	0.5	CON	0.5	100.0%
4b	CON		RAD	0	CON	0.5	50.0%
4c	NC		NC	0.5	CON	0	50.0%
4d	FC		FC	0.5	FC	0.5	100.0%
5	c		c	1	c	1	100.0%
6	d		b	0	b	0	0.0%
7	b		b	1	b	1	100.0%
8	a		d	0	a	1	50.0%
9	d		c	0	d	1	50.0%
10	b		b	1	b	1	100.0%
11	c		c	1	c	1	100.0%
12	d		d	1	d	1	100.0%
13	d		a	0	a	0	0.0%
14	c		c	1	c	1	100.0%
15	c		c	1	c	1	100.0%
16	a		a	1	a	1	100.0%
17	b		d	0	a	0	0.0%
18	c		c	1	c	1	100.0%
				14.5		**16.5**	**20**
				72.5%		**82.5%**	

Cornell University

September 1999 Examination

Question	Answer	Answer	Martin Moravek		Martin Skup		
1a	Test		Test	0.5	Test	0.5	100.0%
1b	Check		Check	0.5	Check	0.5	100.0%
1c	Cal		Cal	0.5	Cal	0.5	100.0%
1d	Check		Check	0.5	Check	0.5	100.0%
2	d		d	1	d	1	100.0%
3	b		b	1	b	1	100.0%
4a	LCO		SL	0	SL	0	0.0%
4b	LSSS		SL	0	SL	0	0.0%
4c	SL		LSSS	0	LSSS	0	0.0%
4d	LCO		LCO	0.5	SL	0	50.0%
5a	6		6	0.5	6	0.5	100.0%
5b	2		2	0.5	4	0	50.0%
5c	1	1/2	4	0	1	0.5	50.0%
5d	2		1	0	4	0	0.0%
6a	water		water	0.25	water	0.25	100.0%
6b	air		air	0.25	air	0.25	100.0%
6c	water		water	0.25	water	0.25	100.0%
6d	fission		fission	0.25	fission	0.25	100.0%
7a	20		20	0.5	20	0.5	100.0%
7b	1		1	0.5	1	0.5	100.0%
7c	1		1	0.5	1	0.5	100.0%
7d	10		10	0.5	10	0.5	100.0%
8	c		a	0	a	0	0.0%
9	c		c	1	c	1	100.0%
10a	2		2	0.25	4	0	50.0%
10b	4		4	0.25	1	0	50.0%
10c	1		1	0.25	3	0	50.0%
10d	3		3	0.25	2	0	50.0%
11	a		a	1	a	1	100.0%
12a	3		3	0.25	3	0.25	100.0%
12b	2		1	0	2	0.25	50.0%
12c	1		2	0	1	0.25	50.0%
12d	4		4	0.25	4	0.25	100.0%
13	b		b	1	b	1	100.0%
14	c		c	1	c	1	100.0%
15	d		d	1	c	0	50.0%
16	c		c	1	c	1	100.0%
				16		**14**	**20**
				80.0%		**70.0%**	

Cornell University

September 1999 Examination

Question	Answer	Answer	Martin Moravek		Martin Skup		
1	d		d	1	b	0	100.0%
2a	2		2	0.5	2	0.5	100.0%
2b	1		1	0.5	1	0.5	100.0%
2c	3		3	0.5	3	0.5	100.0%
2d	4		4	0.5	4	0.5	100.0%
3	a		a	1	a	1	100.0%
4a	1		1	0.5	1	0.5	100.0%
4b	2		2	0.5	2	0.5	100.0%
4c	4		4	0.5	4	0.5	100.0%
4d	5		5	0.5	5	0.5	100.0%
5	c		c	1	a	0	50.0%
6	b		b	1	b	1	100.0%
7	b		b	1	b	1	100.0%
8	d		d	1	a	0	50.0%
9	b	a	a	1	a	1	100.0%
10	b		b	1	b	1	100.0%
11	d		d	1	a	0	50.0%
12	d		d	1	d	1	100.0%
13	b		b	1	b	1	100.0%
14	d		d	1	d	1	100.0%
15	a		a	1	a	1	100.0%
16	d		d	1	d	1	100.0%
17	d		d	1	d	1	100.0%
18	c		c	1	c	1	100.0%
				20		**16**	**20**
				100.0%		**80.0%**	
Test Totals				**50.5**		**46.5**	**60**
				84.2%		**77.5%**	

84.16
6) 50.50
48
25
24
10
6
40
36