

Physics/Global Studies 280
Nuclear Weapons, Nuclear War, and Arms Control

Midterm Examination

2010 March 18

Full Name _____

UIUC ID No. _____

- This is a closed book examination—you are not to consult any materials other than the exam itself, or any person. Giving or receiving unauthorized help is a violation of the University's rules on academic integrity.
- You will have 90 minutes to complete it.
- Answer all the questions on all 10 topics. Each topic counts 20 points.
- The point value of each question within a topic is indicated by a boldface number in square brackets, e.g., [2].
- Write your answers in the spaces provided below each question. *Do not submit any additional pages.* If you need more room, write on the back of the preceding page.
- To receive full credit for definitions, give numbers where relevant.

Scores

- | | |
|---------------|----------------|
| 1. _____ [20] | 6. _____ [20] |
| 2. _____ [20] | 7. _____ [20] |
| 3. _____ [20] | 8. _____ [20] |
| 4. _____ [20] | 9. _____ [20] |
| 5. _____ [20] | 10. _____ [20] |

Total _____ [200]

1. Nuclear physics [20]

(a) Complete the following one-sentence definitions: [10]

i. A fissionable nuclide is

ii. A fissile nuclide is

iii. A fertile nuclide is

iv. A nuclear-explosive nuclide is

v. A nuclear-explosive *material* is

(b) Are all fissile nuclides nuclear-explosive nuclides? (Yes or No) [2]

(c) Are there any nuclear-explosive nuclides that are not fissile? (Yes or No) [2]

(d) Can the timing of a spontaneous fission event be controlled? (Yes or No) [2]

(e) What isotope of uranium is most common in nature? [2]

(f) What naturally-occurring isotope of uranium is fissile? [2]

2. Nuclear weapons [20]

- (a) Define the following materials in terms of the percentage of U-235 they contain: **[6]**
- i. low-enriched-uranium (LEU) —

 - ii. highly-enriched uranium (HEU) —

 - iii. weapon-grade uranium —
- (b) Define the following materials in terms of the percentage of Pu-239 they contain: **[4]**
- i. reactor-grade plutonium —

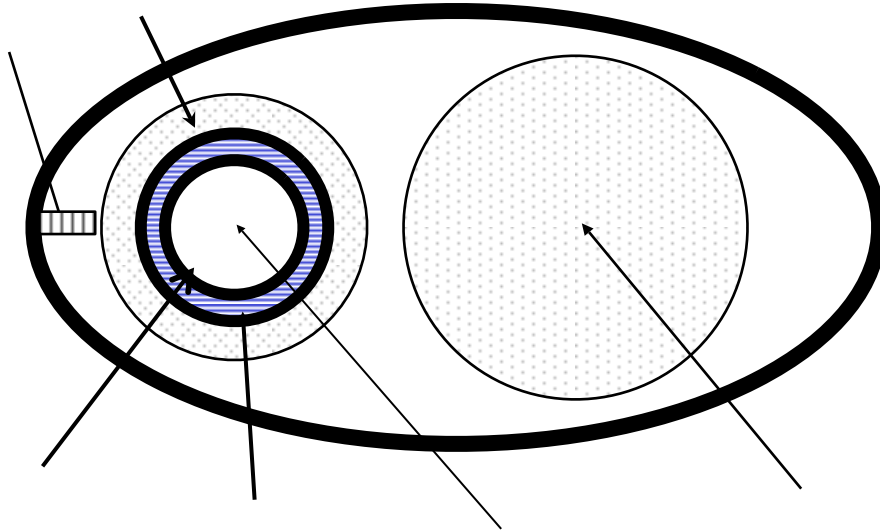
 - ii. weapon-grade plutonium —
- (c) What is the currently preferred technology for producing weapon-grade uranium? **[2]**
- (d) What is the currently preferred technology for producing weapon-grade plutonium? **[2]**
- (e) List three of the physical factors that determine the critical mass of an aggregate of nuclear explosive material. **[6]**
- i.

 - ii.

 - iii.

3. True thermonuclear weapons [20]

- (a) Shown below is a simplified schematic diagram of a true thermonuclear weapon. Number the arrows in the diagram from 1 to 6 to indicate the locations of the following major weapon components: [1] the neutron-emitting initiator, [2] the high-explosive lens assembly, [3] the tamper/reflector, [4] the hollow shell (“pit”) made of nuclear-explosive material, [5] the boost gas (present when the weapon is detonated), and [6] the fusion packet. [6]



Answer the following questions in a single sentence.

- (b) What is the “primary” and why is it called this? [2]
- (c) What is the “secondary” and why is it called this? [2]
- (d) What is the function of the high-explosive lens assembly? [2]
- (e) What is the function of the tamper/reflector? [2]
- (f) What is the function of the initiator? [2]
- (g) What does the boost-gas do? [2]
- (h) What role does the bomb casing play if it is made of depleted uranium? [2]

4. Nuclear explosions and their effects - I [20]

(a) Complete the following one-sentence definitions: [4]

i. An airburst is

ii. A surface burst is

(b) Which produces more fallout, an airburst or a surface burst? [2]

(c) List in the correct time sequence two of the stages in the formation of a mushroom cloud. [4]

i.

ii.

(d) List five harmful physical phenomena produced by a 1-Mt airburst in the order they are produced and give the percentage of the total energy yield in each. [10]

i.

ii.

iii.

iv.

v.

5. Nuclear explosions and their effects – II [20]

(a) The biological effect of a physical dose of radiation depends on four factors. Name two. [4]

i.

i.

(b) Indicate by circling them which of the following are significant sources of radiation exposure for substantial segments of the general U.S. population. [10]

i. Cosmic rays

ii. Medical X-rays

iii. Radioactive elements in their bodies

iv. Radioactive gases in their homes and workplaces

v. Nuclear power plants

(c) List the *general* effect on the human body of the following whole-body radiation doses. [6]

i. 300 rem

ii. 450 rem

iii. 1,000 rem

6. Terrorism and its characteristics [20]

(a) Give a one-sentence definition of each of the following terms: **[8]**

i. Terrorism

ii. State terrorism

iii. State-sponsored terrorism

iv. War terrorism

(b) Richardson argues that a “lethal cocktail” of three factors produces terrorism. List them. **[6]**

i.

ii.

iii.

(c) Richardson argues that although the long-term goals of terrorists differ, almost all terrorists share three short-term goals. List them. **[6]**

i.

ii.

iii.

7. Nuclear terrorism [20]

- (a) State in one sentence the most effective way to prevent nuclear terrorism. [4]
- (b) List two properties of reactor-grade plutonium that complicate its use as a nuclear-explosive material. [4]
- i.
 - ii.
- (c) A difficulty in screening for nuclear bombs is that some common innocuous substances are radioactive and cause false alarms. Name one such substance. [2]
- (d) In his book *Nuclear Terrorism*, Graham Allison lists three “No’s” that he argues must be accomplished to prevent nuclear terrorism. List them. [6]
- i.
 - ii.
 - iii.
- (e) In *Nuclear Terrorism*, Allison lists seven “Yes’s” that he argues must be accomplished to achieve his three “No’s”. List any two of his seven “Yes’s”. [4]
- i.
 - ii.

8. Nuclear weapon delivery methods [20]

- (a) Can a nuclear-armed cruise missile be recalled after it has been launched? (Yes or No) [1]
- (b) Can a nuclear-armed ballistic missile be recalled after it has been launched? (Yes or No) [1]
- (c) On U.S. submarines with nuclear-armed long-range ballistic missiles, who must give the order for them to be launched? [2]

Answer the following two questions in a phrase or a sentence, as appropriate.

- (d) List two methods for delivering nuclear weapons that are among those the U.S. intelligence community assesses are most likely to be used to attack the territory of the U.S. [4]
- i.
 - ii.
- (e) List two reasons an attacker is likely to prefer one of these methods over other methods. [4]
- i.
 - ii.
- (f) Decode the following initializations and list the ranges that define these missile types. [8]
- i. ICBM
 - ii. SRBM
 - iii. MRBM
 - iv. IRBM

9. Nuclear proliferation [20]

(a) Circle the provisions listed below that are provisions of the NPT. [5]

i. Nuclear weapon states (NWS) can keep the nuclear weapons they currently have.

ii. Non-nuclear weapon states (non-NWS) can enrich uranium and operate reactors.

iii. NWS can give nuclear weapons to a non-NWS only with IAEA approval.

iv. Any party can withdraw from the NPT after giving proper notice.

v. Non-NWS are not allowed to operate reactors that can produce plutonium.

(b) Which countries that are not parties to the NPT are thought to have nuclear weapons? [5]

(c) What new approach to nonproliferation (the so-called “Bush Doctrine”) was adopted by the George W. Bush administration in its 2002 National Security Strategy statement? [4]

(d) What is such a policy called in international law? [4]

(e) Indicate which statement below is correct by circling it. [2]

The Bush policy is consistent with international law.

The Bush policy violates international law.

10. Current events [20]

- (a) What important category of nuclear weapons will not be covered by the strategic nuclear arms treaty currently being negotiated between the United States and Russia? **[3]**
- (b) About how many of these weapons does Russia currently have? **[2]**
- (c) About how many of these weapons has the U.S. currently deployed? **[2]**
- (d) Name three countries in which the U.S. currently has these weapons deployed. **[3]**
- i.
 - ii.
 - iii.
- (e) About how many troops does the current U.S. army field manual say are required for every 1 million inhabitants, to successfully suppress an insurgency in a country? **[2]**
- (f) According to the current U.S. army field manual, about how many troops would be required to suppress the insurgency in Afghanistan? **[2]**
- (g) What is the name of the main U.S.-based system intended to defend against long-range ballistic missiles? **[2]**
- (h) Where in the United States is this system based? **[2]**
- (i) In January 2010 this system was tested for the first time in more than a year. Was the test a success or a failure? **[2]**