

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

Midterm Examination

2012 March 15

Full Name _____

UIUC ID No. _____ Lab 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 this examination.
- 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.
- Questions with multiple possible answers will be scored using right minus wrong scoring.

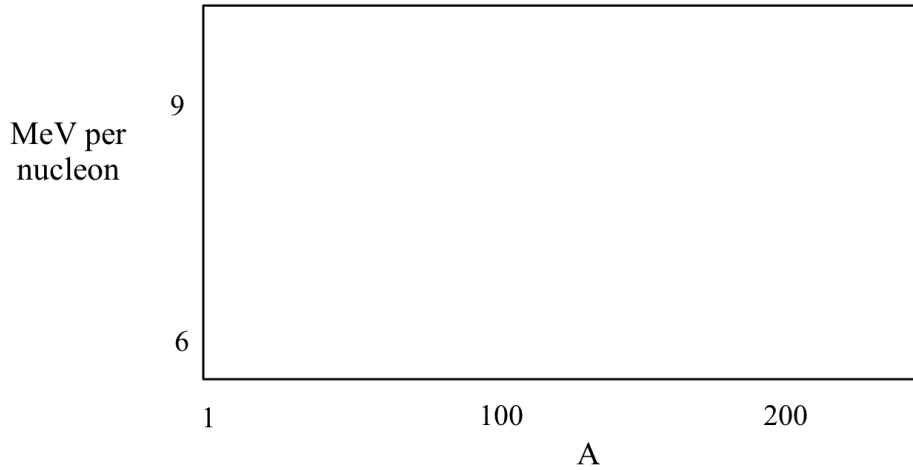
Scores

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) In the panel below, sketch the curve of binding energy per nucleon from $A=1$ to $A=240$. [3]



(b) Label on the panel above the approximate range(s) of A where *fission* can occur. [2]

(c) Label on the panel above the approximate range(s) of A where *fusion* can occur. [2]

(d) Match the type of nuclide listed on the left with the property listed on the right: [6]

fissile	fissioned only by a neutron with sufficient energy
fissionable but not fissile	becomes fissile by absorbing a neutron
fertile	fissioned by a neutron with any energy

(e) Which nuclear process is used to increase the energy yield in a boosted-fission weapon? [2]

spontaneous fission	induced fission	fusion	radioactive decay
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(f) Which subatomic particle is not present in any atomic nucleus? [1]

proton	electron	neutron
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(g) Are all fissile nuclides nuclear-explosive nuclides? [1]

Yes	No
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(h) Are there any nuclear-explosive nuclides that are not fissile? [1]

Yes	No
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(i) What isotope of uranium is most common in nature? [1]

(j) Is the isotope of uranium that is most common in nature fissile? [1]

Yes	No
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2. Nuclear materials [20]

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

 - ii. highly-enriched uranium (HEU) —

 - iii. weapons-grade uranium —
- (b) What is the currently preferred technology for producing weapons-grade uranium? [1]
- (c) Define the following materials in terms of the percentage of Pu-239 they contain: [4]
- i. reactor-grade plutonium —

 - ii. weapons-grade plutonium —
- (d) What are the two main steps involved in producing weapons-grade plutonium? [2]
- i.
 - ii.
- (e) The minimum amount of weapons-grade plutonium needed to make a nuclear bomb is about the same size as a [1]
- pea marble baseball basketball big beach ball
- (f) List three physical aspects of a configuration that influence the amount (mass) of nuclear explosive material needed to have a critical mass. [6]
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4. Nuclear explosions and their effects - I [20]

- (a) The explosive energy of a given mass of nuclear-explosive material is about how many times greater than the energy of an equal mass of conventional high explosives? [2]

100 times 1,000 times 10,000 times 100,000 times 1 million times

- (b) The fundamental limit to the yield of a modern, two-stage nuclear weapon is about [2]

100 kilotons 500 kilotons 1 Megaton 10 Megatons there is none

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

i. An airburst is

ii. A surface burst is

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

- (e) List *five harmful physical phenomena* produced by a 1-Mt airburst and give *the approximate final percentage of the total energy yield in each*. [10]

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6. Terrorism and its characteristics [20]

(a) Complete the following definition: [4]

In Physics 280, terrorism is defined as

(b) Define the following types of terrorism and give a current or historical example of each: [6]

i. State terrorism

ii. State-sponsored terrorism

ii. War terrorism

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

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(d) Name any two of the six basic rules Richardson gives for countering sub-state terrorism: [4]

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7. Nuclear terrorism [20]

- (a) List the three basic terrorist pathways to a nuclear bomb discussed in Ferguson's book *Preventing Catastrophic Nuclear Terrorism* and in the lecture-discussions: [6]
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- (b) What type of nuclear weapon design would be easiest for a terrorist group to construct? [2]
- (c) What type of nuclear explosive material would the group need to make this design work? [2]

Parts (d)–(g) refer to the docudrama “Last Best Chance” shown in class.

- (d) List two of the methods by which the terrorists in the docudrama were able to transport nuclear weapons into the United States. [2]
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- (e) What Russian response did the U.S. president fear if the terrorists successfully detonated a nuclear bomb in Russia? [1]
- (f) Although the border guard scanned the cargo with a radiation detector, he failed to detect the nuclear bomb. Why? [1]
- (g) State in one sentence the most effective way to prevent terrorists from getting a nuclear bomb. [2]
- (h) Graham Allison and other nuclear terrorism experts argue that we must insist on “Three No’s” to prevent nuclear terrorism. List any two of them. [4]
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8. Nuclear weapon delivery methods [20]

(a) Can a nuclear-armed cruise missile be recalled after it has been launched? [1]

Yes

No

(b) Can a nuclear-armed ballistic missile be recalled after it has been launched? [1]

Yes

No

(c) Is there any physical barrier to prevent the crew of a U.S. submarine carrying nuclear-armed long-range ballistic missiles from launching them without Presidential authority? [2]

Yes

No

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 United States. [4]

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(e) The most recent U.S. National Intelligence Estimate of the ballistic missile threat to the United States gives several reasons why an attacker is likely to prefer one of the methods asked for in part (d) over other methods. List two of these reasons. [4]

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(f) Decode the following initializations and list the ranges that define these missile types. [8]

i. IRBM

ii. ICBM

iii. MRBM

iv. SRBM

9. Nuclear Proliferation [20]

(a) List the year in which each of the following countries first created a nuclear explosion. [8]

United States:	China:	United Kingdom:	Pakistan:
Soviet Union:	France:	North Korea:	India:

(b) List three states that once had nuclear weapons but gave them up. [3]

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(c) Indicate which if any of the following actions are permissible under International Law by circling the sentence that describes the action. [3]

attacking a country that is blockading your territory

attacking a country to prevent it from launching an attack at some time in the future

attacking a country to disrupt an attack on you that is already underway or is imminent

(d) List the States that currently have nuclear weapons and either never signed the Nuclear Nonproliferation Treaty or later withdrew from it. [4]

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(e) Is it possible to make a functioning nuclear weapon using reactor-grade plutonium? [2]

Yes

No

10. Current events [20]

(a) List three arguments that have been made for attacking Iran's nuclear facilities now. [3]

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(b) List three arguments that have been made against attacking Iran's nuclear facilities now. [3]

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(c) In President Obama's FY13 budget request, funding for the National Nuclear Security Administration's program to provide radiation detectors to foreign nations is being [2]

substantially decreased kept about the same substantially increased

(d) In President Obama's FY13 budget request, funding for the Nuclear and Radiological Material Removal program to secure nuclear materials against terrorists is being [2]

decreased kept about the same increased

(e) About how many strategic nuclear weapons do the United States and Russia currently have *deployed*? [4]

United States

Russia

(f) What is the limit on the number of strategic nuclear weapons the United States and Russia can have *deployed* in 2018, under the terms of the New START treaty? [4]

United States

Russia

(g) What is President Obama's announced long-term goal for the number of nuclear weapons in the world? [2]