

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

Midterm Examination

2013 March 14

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) Is the most common uranium isotope occurring in nature fissile? (Yes or No) [1]

(g) What distinguishes isotopes of the same element? [1]

i. the mass number A

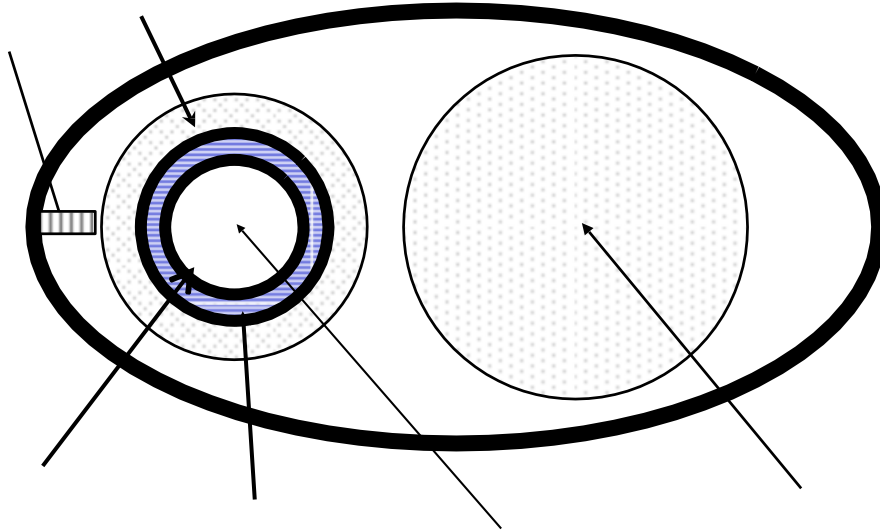
ii. the number of protons Z

2. Nuclear Materials [20]

- (a) Identify the two most common fissile isotopes, the first uranium and the second plutonium, used for making fission weapons. [4]
- (b) Define the following materials in terms of the percentages of the above isotope of uranium they contain: [6]
- i. Low enriched uranium (LEU)
 - ii. Highly enriched uranium (HEU)
 - iii. Weapons-grade uranium
- (c) True or False: The only use for HEU is making nuclear weapons. [2]
- (d) Detecting HEU in a hidden and shielded nuclear weapon is [2]
- i. Easy because it's radioactive radiation is highly penetrating
 - ii. Difficult because it's radioactive radiation is not highly penetrating
 - iii. Impossible because it's not radioactive at all
- (e) Define the following materials in terms of the percentages of the above isotope of plutonium they contain: [2]
- i. Reactor-grade plutonium
 - ii. Weapons-grade plutonium
- (f) Plutonium is dangerous to work with because [2]
- i. It's highly radioactive
 - ii. It's toxic in very small quantities
 - iii. Both i. and ii.
- (g) True or false: Reactor-grade plutonium cannot be used to make a nuclear explosion. [2]

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 [20]

- (a) List four harmful physical phenomena produced by a 1-Mt airburst in the order they occur 1000 feet away from ground zero and give the percentage of the total energy yield in each. [12]
- i.
 - ii.
 - iii.
 - iv.
- (b) Which produces more fallout, an airburst or a surface burst? [2]
- (c) A nuclear attack on a country would loft soot into the upper atmosphere, screening sunlight and reducing surface temperatures around the Earth. About how long would it take for half the soot to fall out of the atmosphere? [3]
- i. 1 month
 - ii. 6 months
 - iii. 1 year
 - iv. 5 years
- (d) The atmospheric effects of the regional nuclear war between India and Pakistan discussed in class would likely reduce the length of the growing season in the U.S. Midwest by [3]
- i. 1%–2%
 - ii. 10%–15%
 - iii. 30%–40%
 - iv. 70%–80%

5. Nuclear Proliferation [20]

- (a) List the year in which each of the following countries first created a nuclear explosion. [8]
- i. United States:
 - ii. China:
 - iii. United Kingdom:
 - iv. Pakistan:
 - v. Soviet Union:
 - vi. France:
 - vii. North Korea:
 - viii. India:
- (b) Give another country, not listed above, that is believed to have created a nuclear explosion: [2]
- (c) List three states that once had nuclear weapons but gave them up. [3]
- (d) Is it easier to create nuclear explosive materials for a uranium based bomb, or a plutonium based bomb? [2]
- (e) Given the nuclear explosive materials is available in either case, is it easier to build an uranium based bomb or a plutonium based bomb? [2]
- (f) Rank in difficulty (by placing numbers beside; 1 is the most difficult and 3 is the least) the following steps involved in creating a nuclear weapon: [3]
- i. acquiring theoretical knowledge of the workings of a nuclear weapon
 - ii. producing nuclear explosive material
 - iii. assembling nuclear explosive material into a nuclear weapon

6. Terrorism and its characteristics [20]

- (a) Terrorism is defined as _____ and _____ targeting _____ for _____ purposes. [2]
- (b) Give a current or historical example of each of the following types of terrorism: [6]
- i. State terrorism
 - ii. State-sponsored terrorism
 - iii. War terrorism
- (c) List three other characteristics terrorism often has. [6]
- i.
 - ii.
 - iii.
- (d) 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) Name two reasons why terrorists are more likely to attack the U.S. with nuclear weapons using non-missile delivery means. [4]
- i.
 - ii.
- (c) List two properties of reactor-grade plutonium that complicate its use as a nuclear-explosive material. [4]
- i.
 - ii.
- (d) A difficulty in screening for nuclear bombs is that some common innocuous substances are radioactive and cause false alarms. Name two such substances. [4]
- (e) In his book *Nuclear Terrorism*, Graham Allison lists three “No’s” that he argues must be accomplished to prevent nuclear terrorism. List two of them. [4]
- i.
 - ii.

8. Nuclear weapon delivery methods - I [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. SLBM
 - iii. SRBM
 - iv. MRBM

9. Nuclear Weapon Delivery Methods - II [20]

(a) Decode the following initializations. [10]

- i. SSBN
- ii. SSGN
- iii. MIRV
- iv. RV
- v. CEP

(b) What is chaff? [4]

(c) What is the CEP of a Trident II, circle the correct answer? [3]

- i. 50 m
- ii. 100m
- iii. 200m

(d) What is the CEP of Russian ICBMs? [3]

- i. 50m
- ii. 100m
- iii. more than 200m ?

10. Current events [20]

- (a) What was the mass of the payload of the Unha-3 missile tested by North Korea successfully in December 2012: (i.) 50 lbs, (ii.) 200 lbs, (iii.) 450 lbs ? [3]
- (b) Therefore, is North Korea currently capable of delivering a nuclear warhead to the continental United State – yes or no? [2]
- (c) Which countries supported the United Nations Security Council (UNSC) sanctions issued against North Korea in January following the missile test? (i.) All 15 members of the (UNSC) but China and Russia, (ii.) all 15 UNSC members, (iii.) all 15 UNSC members but China. [2]
- (d) Name three countries that may be within reach of North Korean missiles. [3]
- i.
 - ii.
 - iii.
- (e) What were the results of the nuclear arms talk between the P5+1 and Iran in Kazakhstan in February? (i.) The meeting ended without an agreement. (ii.) The meeting ended with an agreement to lift some of the sanctions in return for Iran's agreement of IAEA inspection to selected nuclear sites. (iii.) the meeting ended without an agreement but with all parties agreeing to additional talks . [2]
- (f) Prior to the meeting in Kazakhstan, Ayatollah Khamenei has made the declaration that (i.) Iran would not seek to build nuclear weapons, (ii.) the IAEA is free to inspect any nuclear site in Iran, (iii.) Iran will stop Uranium enrichment if UN sanction should be dropped. [2]
- (g) North Korea carried out a 3rd nuclear test in February 2013. Was the yield of the weapon tested (i.) ~ 2kT, (ii.) ~ 7kT or (iii.) ~15kT? [2]
- (h) Is this yield consistent with the possible usage of a miniaturized nuclear warhead, yes or no? [2]
- (i) Describe North Korea's reaction to the UN sanctions following its last nuclear weapons test? [2]