

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

**Final Examination**

**2010 May 13**

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 have the full exam period (180 minutes) to complete it.
- Answer all the questions on all 15 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. _____ <b>[20]</b>	6. _____ <b>[20]</b>	11. _____ <b>[20]</b>
2. _____ <b>[20]</b>	7. _____ <b>[20]</b>	12. _____ <b>[20]</b>
3. _____ <b>[20]</b>	8. _____ <b>[20]</b>	13. _____ <b>[20]</b>
4. _____ <b>[20]</b>	9. _____ <b>[20]</b>	14. _____ <b>[20]</b>
5. _____ <b>[20]</b>	10. _____ <b>[20]</b>	15. _____ <b>[20]</b>

Total \_\_\_\_\_ **[300]**

**1. Nuclear explosive materials – I [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) What is the main reason weapons-grade HEU would be the nuclear explosive material of choice for countries or non-state groups with very low technological capability? [3]

(e) What is one reason weapons-grade plutonium would be the nuclear explosive material of choice for countries with high technological capability? [3]

**2. Nuclear explosive materials – II [20]**

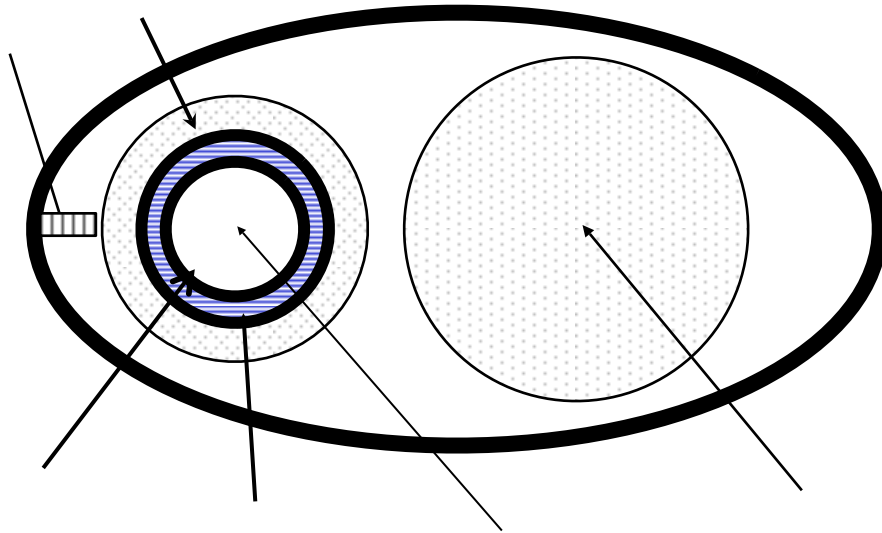
- (a) What isotope of uranium is most common in nature? [2]
- (b) What is the most common naturally-occurring isotope of uranium that is fissile? [2]
- (c) Define the following uranium materials in terms of the percentage of U-235: [6]
- i. low-enriched-uranium –
  - ii. weapons-usable HEU –
  - iii. weapons-grade HEU –
- (d) Define the following plutonium materials in terms of the percentage of Pu-239: [6]
- i. reactor-grade plutonium –
  - ii. fuel-grade plutonium –
  - iii. weapons-grade plutonium –
- (e) Is the quantity of weapons-usable HEU the IAEA considers a “significant quantity” (i.e., a quantity that if missing would be of concern) much smaller, about the same, or much larger than the quantity of HEU needed by a country with medium technical capability to construct a 20-kt bomb? [2]
- (f) Is the quantity of weapons-grade plutonium the IAEA considers a “significant quantity” (i.e., a quantity that if missing would be of concern) much smaller, about the same, or much larger than the quantity needed by a country with medium technical capability to construct a 20-kt bomb? [2]

**3. Modern 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) Which part of the bomb could greatly increase the radioactive fallout? [2]



**4. Nuclear explosions [20]**

- (a) About how many times more powerful is a nuclear bomb than a high-explosive bomb of the same mass? [2]
- (b) List two properties of reactor-grade plutonium that complicate its use as a nuclear-explosive material. [4]
- i.
  - ii.
- (c) When the energy released by a nuclear explosion is stated in “kilotons”, with what is it being compared? [2]
- (d) If a 10-kiloton nuclear bomb were exploded in midtown Manhattan [4]
- i. Roughly how many people could be killed immediately? (Circle the right answer.)  
10      30,000      3,000,000
  - ii. Roughly how large an area would be reduced to rubble? (Circle the right answer.)  
0.001 square km      10 square km      300 square km
- (e) Which of the following are *nuclear* radiations? (Circle the right answers.) [4]
- Radio      Optical      Alpha      Beta      Gamma      Neutron      X-ray
- (f) The *relative biological effectiveness* (RBE) indicates the biological damage produced by a given physical dose of radiation. The RBE depends on four factors. List two of them. [4]
- i.
  - ii.

**5. Terrorism [20]**

(a) Give one-sentence definitions of each of the following terms: **[6]**

i. State terrorism

ii. State-sponsored terrorism

iii. War terrorism

(b) Why is the phrase “war on terror” nonsensical? **[2]**

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

**6. Nuclear terrorism [20]**

The docudrama “Last Best Chance” shown in class illustrated the threat of nuclear terrorism.

(a) List two countries from which the terrorists in the film obtained nuclear bomb material. [2]

i.

ii.

(b) List two of the methods by which terrorists were able to transport nuclear weapons into the United States: [2]

i.

ii.

(c) What Russian response did the U.S. president fear if the terrorists detonated a nuclear bomb in Russia? [1]

(d) Although the border guard scanned the cargo with a radiation detector, he failed to detect the nuclear bomb. Why? [1]

(e) A difficulty in screening for nuclear bombs is that some common innocuous substances are radioactive and cause false alarms. Name two such substances. [2]

i.

ii.

(f) 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.

(g) In *Nuclear Terrorism*, Allison lists seven “Yes’s” that he argues must be accomplished to achieve his three “No’s”. List any three of his “Yes’s”. [6]

i.

ii.

iii.



**7. Nuclear arsenals [20]**

- (a) The United States currently has how many active and inactive nuclear weapons in its stockpile? [2]
  
- (b) The United States currently has how many *strategic* nuclear weapons deployed? [2]
  
- (c) The United States currently has how many *tactical* nuclear weapons in Europe? [2]
  
- (d) Russia currently has how many active and inactive nuclear weapons in its stockpile? [2]
  
- (e) Russia currently has how many *strategic* nuclear weapons deployed? [2]
  
- (f) Russia currently has how many *tactical* nuclear weapons? [2]
  
- (g) China currently has how many nuclear weapons in total? [2]
  
- (h) France currently has how many nuclear weapons in total? [2]
  
- (i) The United Kingdom currently has how many nuclear weapons in total? [2]
  
- (j) Israel currently has about how many nuclear weapons in total? [2]

**8. India's and Pakistan's nuclear arsenals [20]**

- (a) In what year did India most recently test a nuclear weapon? [2]
  
- (b) India is thought to have about how many nuclear weapons? [2]
  
- (c) Are India's nuclear weapons thought to use uranium or plutonium? [2]
  
- (d) What is the range of the longest-range missile India has successfully tested? [2]
  
- (e) What nuclear delivery method would India most likely use if it attacked Pakistan? [2]
  
  
  
  
  
  
  
  
  
  
- (f) In what year did Pakistan most recently test a nuclear weapon? [2]
  
  
- (g) Pakistan is thought to have about how many nuclear warheads? [2]
  
  
  
  
  
  
  
  
  
  
- (h) Are Pakistan's nuclear weapons thought to use uranium or plutonium? [2]
  
  
  
  
  
  
  
  
  
  
- (i) What is the range of the longest-range missile Pakistan has successfully tested? [2]
  
  
  
  
  
  
  
  
  
  
- (j) What nuclear delivery method would Pakistan most likely use if it attacked India? [2]

**9. North Korea and Iran's nuclear and missile programs [20]**

- (a) In a National Intelligence Estimate, which of the following adjectives indicate a greater than even chance that a judgment is correct? (Circle the right answers.) [2]

Might    May    Probably    Very likely

- (b) In 2002, North Korea was thought to have enough plutonium to make about how many nuclear weapons? (Circle the right answer.) [2]

1 or 2            5 or 6            6–10            10–15            30–40

- (c) In 2002, North Korea's plutonium was under IAEA safeguards and unavailable for use in nuclear weapons. That year President George W. Bush publicly insulted the leader of North Korea, labeled North Korea part of "an axis of evil", canceled ongoing nuclear negotiations with North Korea, and ended the 1994 Agreed Framework. List two of the most important unilateral actions North Korea took in response. [2]

i.

ii.

- (d) By 2005, North Korea was thought to have enough plutonium to make about how many nuclear weapons? (Circle the right answer.) [2]

1 or 2            5 or 6            6–10            10–15            30–40

- (e) What is the range in km of the longest-range missile North Korea has deployed? [2]

- (f) Could this missile reach any part of the United States? (Yes or No.) [2]

- (g) What fissile material is Iran currently seeking to produce? [2]

- (h) What technology is Iran currently using to produce this fissile material? [2]

- (i) What is the range in km of the longest-range missile Iran has deployed? [2]

- (j) Could this missile reach any part of the United States? (Yes or No.) [2]

**10. History of U.S. missile defense programs [20]**

- (a) When did the United States first declare a missile defense system “operational”? [2]
- (b) About how long was that system operational? [2]
- (c) About how much, in 2008 dollars, has the United States spent so far on missile defenses? [2]
- (d) Have any of the systems the U.S. has tested or deployed proved effective? (Yes or No.) [2]
- (e) Which of the following was *not* a lesson of the Star Wars program? (Strike it out.) [2]  
 Building an effective missile defense is a very challenging task  
 The technology required cannot be created by wishful thinking  
 An R&D program without clear goal wastes time and money  
 Frequent testing of missile defense components is unnecessary  
 An independent evaluation and review process is critical for success
- (f) Which of the following was *not* a consequence of the Star Wars program? (Strike it out.) [2]  
 The public developed unrealistic hopes for a perfect shield against long-range missiles  
 The already enormous federal budget deficit was greatly increased  
 The Soviet Union and China moved to increase the size and capability of their missiles  
 The Soviet Union collapsed economically
- (g) The reported success of the Patriot system during the 1991 Gulf War was a key argument used to restart the U.S. program to intercept ICBMs. About how many intercepts of Iraqi short- range missiles during the war are well-documented? (Circle the correct answer.) [2]  
 0                      1                      3                      12                      73
- (h) How many of its 6 testing objectives for 2008 did the Missile Defense Agency achieve? [2]  
 0      1      2      3      4      5      6
- (i) In 2004, President Bush deployed ground-based midcourse interceptor rockets in Alaska and California that were intended to defend against intercontinental-range ballistic missiles.
- i. Tests of this system have been highly scripted and unrealistic, but even so the percentage of tests that have been declared successful is only (circle the right answer) [2]  
 10%                      20%                      40%                      60%                      80%
- ii. List two countermeasures an adversary could use to defeat this system. [2]
- -

**11. Current U.S. missile defense programs [20]**

- (a) Circle the actions the Obama administration is taking with respect to the ground-based midcourse defense system that is being built in Alaska and California. [8]

Converting ICBM silos at Vandenberg AFB in California to house interceptor rockets

Building new interceptor silos at Ft. Greeley in Alaska

Purchasing additional interceptor rockets for the silos at Ft. Greeley

Upgrading the Clear (Alaska) and Thule (Greenland) ABM battle-management radars

- (b) President Bush planned to deploy a midcourse intercept defense system in Europe. [4]

i. What threat was this system supposed to counter?

ii. The interceptor rockets for this system were

- Tested about a dozen times
- Tested three times
- Tested once
- Never built

- (c) President Obama cancelled Bush's planned midcourse intercept defense system in Europe and is deploying a different system that will rely primarily on (circle the right answers) [8]

Large ground-based interceptor rockets

Small ship-based interceptor rockets

Ship-based lasers

Airborne lasers

**12. Nuclear arms control – I [20]**

- (a) What is the difference between an Executive Agreement and a Treaty? [2]
- (b) Does a state that has signed a treaty have to comply with it even if the state has not ratified the treaty? (Yes or No) [2]
- (c) The Limited Test Ban Treaty was first signed in what year? [2]
- (d) What was the main provision of the Limited Test Ban Treaty? [2]
- (e) Is the Limited Test Ban Treaty still in force? (Yes or No.) [2]
- (f) What year was the nuclear Non-Proliferation Treaty (NPT) opened for signature? [2]
- (g) What was the main provision of the NPT to which the nuclear-weapon states agreed? [2]
- (h) What was the main provision of the NPT to which the non-nuclear-weapon states agreed? [2]
- (i) Which of the following countries are *not* currently parties to the NPT? [circle them] [4]  
Brazil    China    Pakistan    India    Iran    Israel    North Korea    South Africa

**13. Nuclear arms control – II [20]**

- (a) What was the main purpose of the Anti-Ballistic Missile Treaty. [2]
- (b) What year was the Anti-Ballistic Missile Treaty signed? [2]
- (c) Which countries signed the Anti-Ballistic Missile Treaty? [2]
- (d) What was the intended duration of the Anti-Ballistic Missile Treaty? [2]
- (e) Is the Anti-Ballistic Missile Treaty still in force? (yes or No.) [2]
- (f) What year was the INF treaty signed? [2]
- (g) Which countries signed the INF treaty? [2]
- (h) What was the range interval (in km) of the nuclear weapons restricted by the INF treaty? [2]
- (i) Why were nuclear weapons with this range considered especially dangerous? [2]
- (j) How many of these weapons was each party to the INF treaty allowed? [2]

**14. Nuclear arms control – III [20]**

(a) Decode the initialization “CTBT”. [2]

(b) What is the purpose of the CTBT. [2]

(c) What year was the CTBT opened for signature? [2]

(d) Has the United States ratified the CTBT? [2]

(e) What is the intended duration of the CTBT? [2]

(f) Is the CTBT currently in force? [2]

(g) What year was the New START treaty signed? [2]

(h) Which category of nuclear weapons is restricted by the New START treaty? [2]

(i) Which countries signed the New START treaty? [2]

(j) About how many of these nuclear weapons is each party to New START allowed? [2]



**15. Current events [20]**

- (a) Which U.S. agency issues the Nuclear Posture Review report? [2]
- (b) What is the purpose of the Nuclear Posture Review report? [2]
- (c) In the 2010 Nuclear Posture Review, the United States renounced the development of any new nuclear weapons. (Yes or No.) [2]
- (d) In the 2010 Nuclear Posture Review, the United States for the first time promised not to use nuclear weapons against what countries? [2]
- (e) What is the “most immediate and extreme danger” in the current international security environment, according to the 2010 Nuclear Posture Review? [2]
- (f) List two important issues related to U.S. nuclear weapons that were *not* addressed by the New START treaty. [6]
- -
- (g) Which nuclear threat was the focus of a meeting this semester in Washington, DC? [2]
- (i) Which arms control treaty is currently under review at the United Nations? [2]